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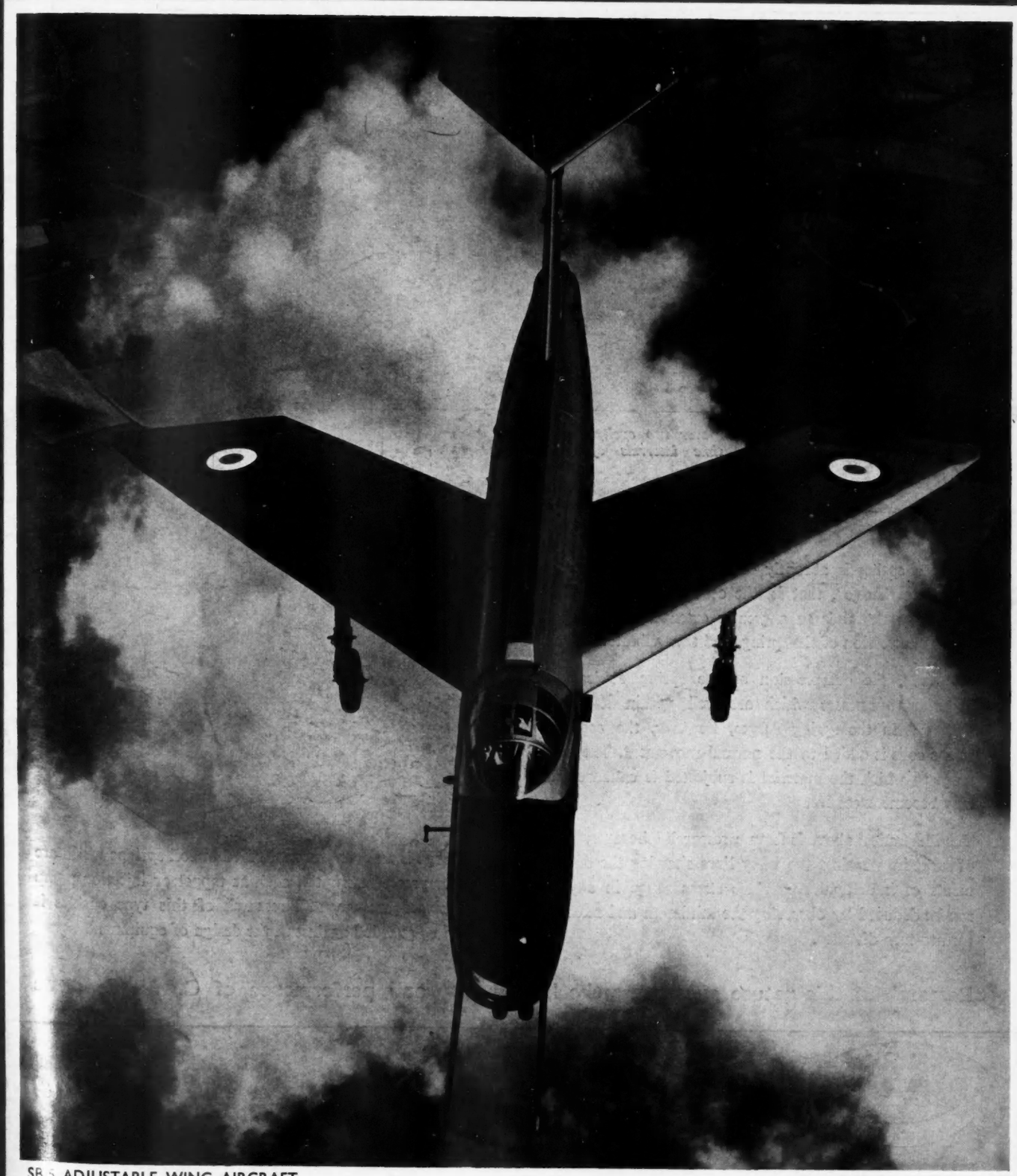
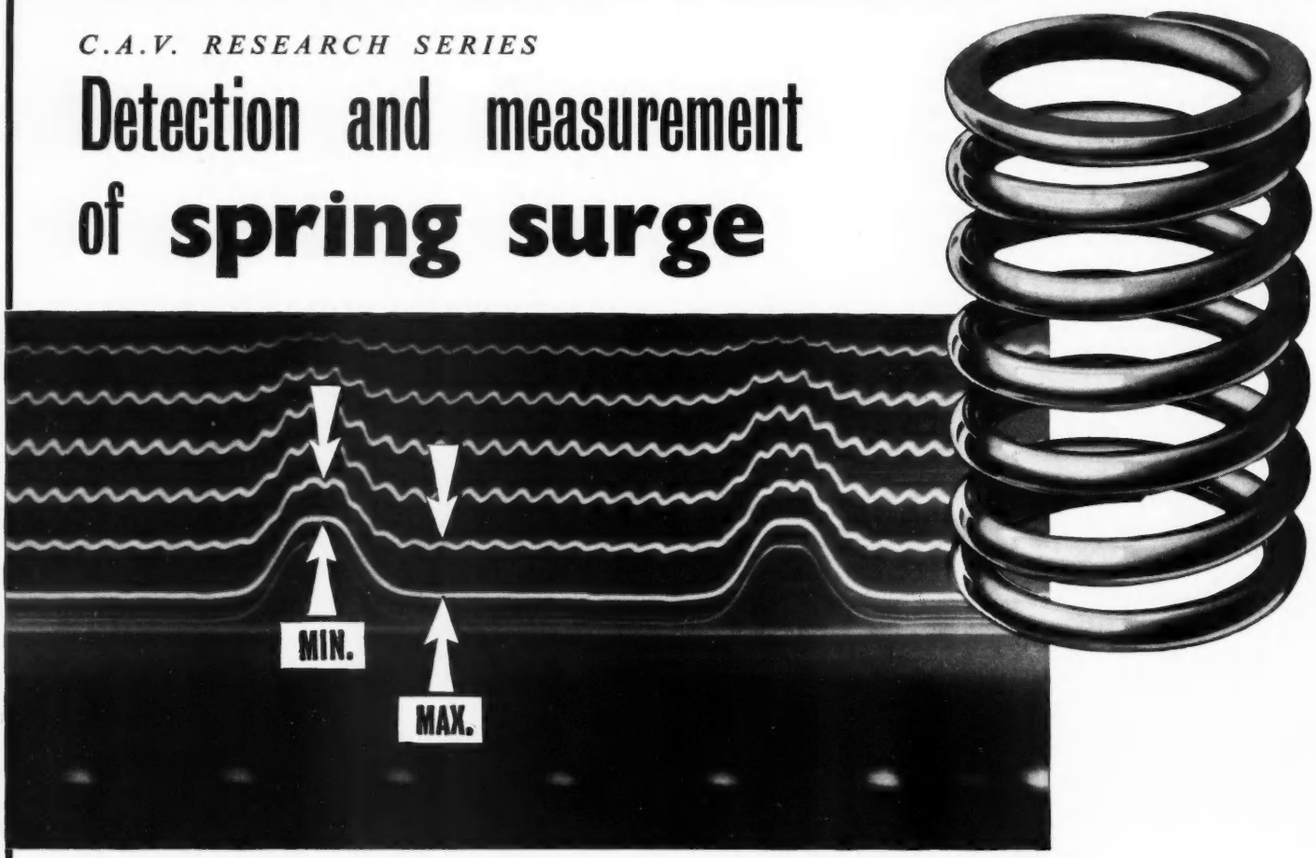


SB 5 ADJUSTABLE WING AIRCRAFT.

C.A.V. RESEARCH SERIES

Detection and measurement of **spring surge**

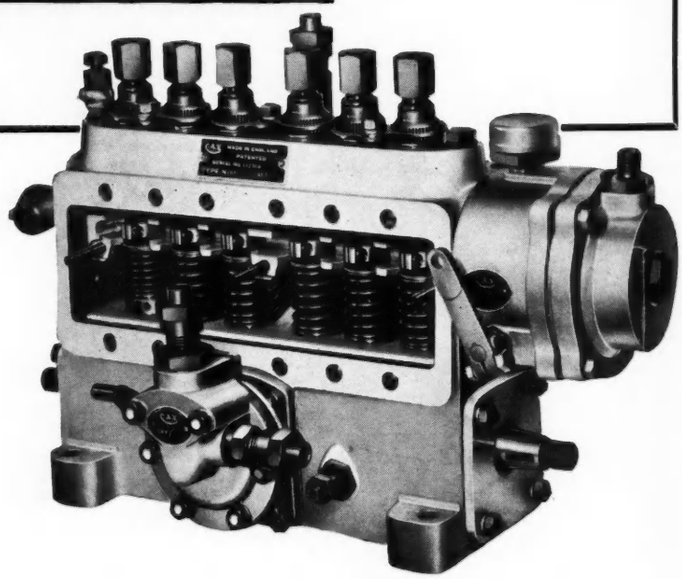


The firm line shows the cam rise over two cycles. The lower dotted trace shows time intervals of 10 milliseconds.

When a spring is abruptly compressed, its coils may be caused to "surge", that is, the centre coils are displaced relative to the ends to a greater extent than during the slow compression of the spring, and then vibrate.

Normally, the compression of the spring subjects the material to stresses which are well within its fatigue limit. When the spring surges, however, the oscillation of the coils is added to the normal movement. The stress-range to which the material is subjected is enhanced, and may become excessive.

The illustration above is from a research laboratory record of surge in a spring, the wavy lines showing the displacements of individual coils. The stress range in any turn can be deduced by observing the minimum and maximum turn-to-turn distance.



Surge is an ever-present hazard in coil springs which are compressed abruptly, such as tappet or injection pump plunger springs, and research of this type enables it to be guarded against in the design of equipment.

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THE YORK RIVER BRIDGE, VIRGINIA, U.S.A.

THE York River, which lies entirely within the State of Virginia, runs into Chesapeake Bay at a point some 20 miles from the mouth of the bay on the Atlantic seaboard. The river is five miles wide at its junction with Chesapeake Bay and varies in width from two to five miles throughout the lower 26 miles of its length. The United States main highway No. 17 runs approximately parallel to the shore of the Bay and formerly crossed the river at Yorktown, some six miles from the mouth, by a ferry. This highway connects the important area around Norfolk Roads with Washington, Baltimore and other large towns in the north. A sketch map showing the situation of the river and Yorktown in relation to the surrounding district is given in Fig. 4, on page 738. The ferry caused serious delays on this important traffic route, the crossing taking half an hour, with long waiting periods at busy times. It has now been replaced by a bridge 3,750 ft. long and incorporating two opening spans. The bridge, a general view of which is given in Fig. 1, on this page, is claimed to be the largest swing-span structure in the world. It has been named the George P. Coleman Memorial Bridge after a former highway commissioner. It was officially opened on May 7, 1952.

Although, as stated above, the river varies in width from two to five miles, on the opposite side from Yorktown, which is south of the river, the projecting Gloucester Point results in a construction only 2,600 ft. wide, as shown in the larger-scale map, Fig. 5, on page 737. It was at this point that the ferry was operated and the bridge has been built. Yorktown is a focal point in American history as it was here that Lord Cornwallis surrendered to George Washington. This event, establishing the independence of the United States, was preceded by the destruction of British transports as they were attempting to ferry troops to Gloucester Point. It is reported that Lord Cornwallis projected the building of a bridge, and if he did he was by no means the last person to consider the matter. Various plans have been put forward in the intervening years by both public and private bodies.

It was only in 1940, however, that a scheme for a bridge began to take practical shape, and in that year the United States War Department issued a permit to the Virginia Department of Highways for the construction of a bridge giving from 120 to 135 ft. vertical clearance and 1,300 ft. horizontal clearance. To meet these requirements, a suspension bridge was designed in 1942. The main span was 1,380 ft. long with side spans each 610 ft. long. The concrete anchorages were located near the banks of the river. When the clearance dimensions were specified by the War Department it had apparently been contemplated that the United States Navy might require to assemble the whole of its Atlantic Fleet in the river above the bridge. The development of air power and war experience, however, made it clear that such a concentration would be highly undesirable, and after the war, as a result of many conferences and discussions, it was agreed that a horizontal clearance of 450 ft. would be sufficient. This decision permitted the abandonment of the suspension-bridge scheme and the building of a low-level bridge at considerably less cost, the necessary vertical clearance for shipping being provided by arranging for swing spans at the centre. Work was started in December, 1949.

An elevation and plan of the bridge are given in Figs. 2 and 3, below. It has two swing spans, each 500 ft. long, which, when moved into the open position, as indicated in Figs. 2 and 3, provide the specified 450-ft. channel between the central piers, which are at 500-ft. centres. The spans on each side of the channel span are 390 ft. long, as shown in Fig. 2, this width being bridged by half the swing spans and 140-ft. cantilevered arms of the spans extending to the next pier 350 ft. away. These anchor spans, carrying the cantilevers that support the ends of the swing spans when they are in the closed position, are also cantilevered out 70 ft. at the shoreward ends, and carry one end of the 210-ft. suspended spans, the other ends of which rest on piers at the river edge. This makes up a length of 280 ft. for the outer spans of the river crossing. The approach on the south side is made up of six plate-girder spans, two 65 ft. long and four 90 ft. long. On the north side, there are eight 90-ft. girder spans. The bridge carries a 26-ft. two-lane roadway, with 2 ft. 6 in. wide kerbs on each side.

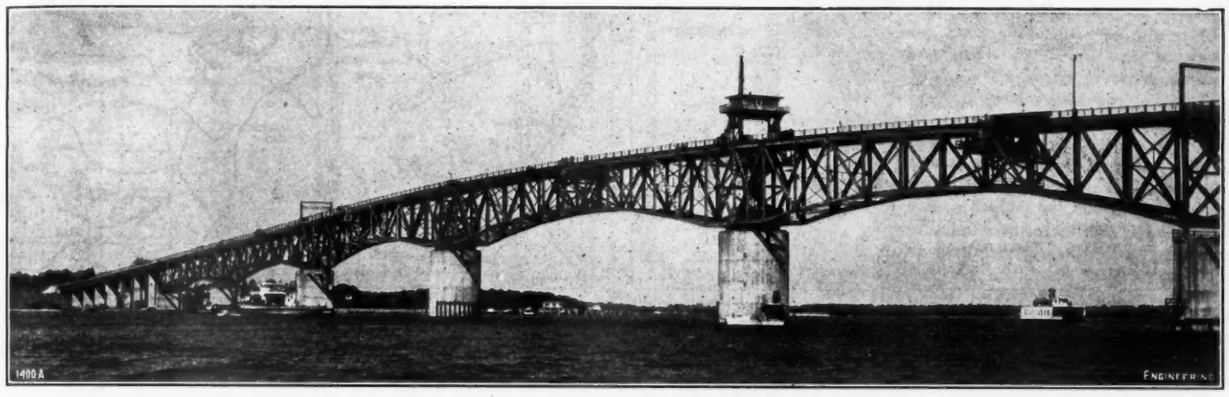


FIG. 1. YORK RIVER BRIDGE.

Fig. 2.

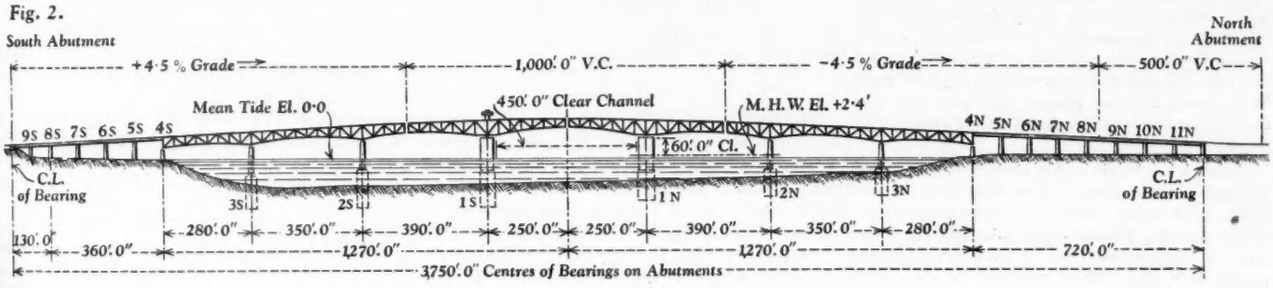
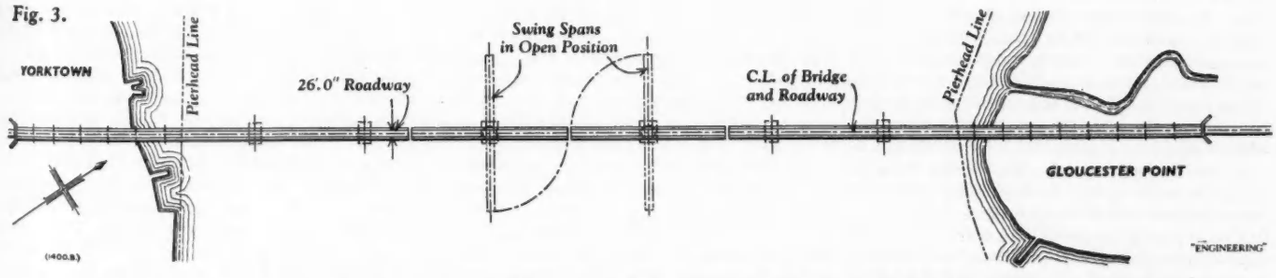


Fig. 3.



PIER FOUNDATIONS.

The provision of adequate foundations for the river piers formed one of the major problems in the construction of the bridge. The depth of water at

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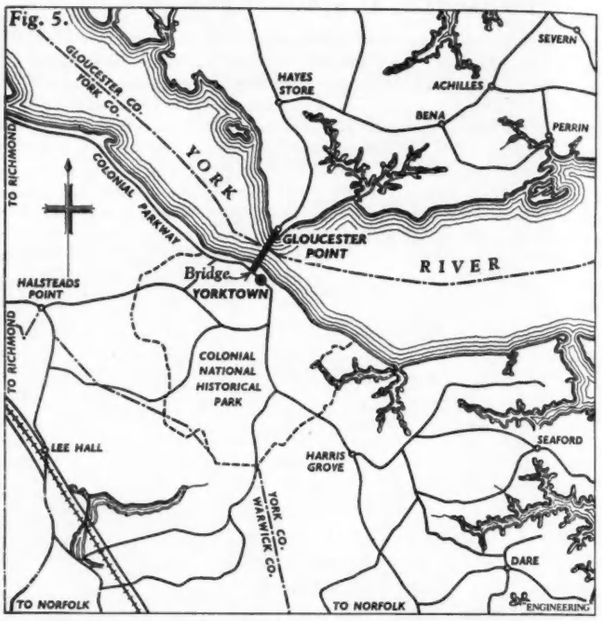
Fig. 4.

Fig. 5.



the site varies from 50 to 80 ft., the average being about 70 ft., and the river bottom is covered with a layer of mud varying in thickness from 10 to 40 ft. Beneath the mud, the bottom consists of fine sand and silt, in some places containing clay and broken shells. This bottom is from 80 to 110 ft. below the water surface. Borings, some carried to a depth of 200 ft. below water level, indicated that the piers would have to rest on strata consisting of fine sand and silt, although at a greater depth support would be furnished by a medium to stiff clay. No rock or boulders were encountered in depths within 200 ft.

The bearing value of the sand and silt is low, and that for the upper portion of the clay beneath is not much higher. Laboratory analysis of undisturbed samples indicated that after making allowance for the buoyancy of the submerged portions of the pier, the bearing pressure for the direct vertical load should not exceed 4 tons per square foot. The differential pressure between the 4-ton intensity under the pier and the intensity of bearing on adjacent soil outside it, and at the same depth as the pier base, is about 2 tons per square foot. Under the action of wind and river currents tending to overturn the pier, the soil pressure along the edge of the base is increased by a maximum of 1·8 tons per square foot, but allowing for skin friction in resisting such loads of short duration it was considered allowable to make a deduction of 0·3 tons per square foot. As a result of these considerations and calculations it was finally decided to adopt a differential soil pressure of 3·3 tons per square foot as a basis for the design of the piers.

To obtain the required penetration for limiting the differential pressure, it was found necessary to sink the bases of the piers to 135 ft. below mean water level for piers 3 S and 3 N and 150 ft. for piers 1 S and 2 S. The various designations for the piers are marked in Fig. 2. The tallest pier, 1 S, is 210 ft. high, and as a column of concrete of 1 ft. square section and 210 ft. high would have a bearing pressure of more than 15 tons per square foot, it was not possible to employ solid piers, and hollow structures were accordingly decided on. Pier 1 S consists of a hollow shell 110 ft. high crowned by a 100-ft. shaft. The shell is of rectangular cross-section with exterior walls 4 ft. thick, and 3 ft. thick interior cross bulkheads. The shaft is a hollow cylinder 44 ft. in diameter with a 3 ft. thick exterior wall and two 3 ft. thick internal bulkheads, at right angles. The upper 5 ft. length of the shaft is solid. This description also applies to the shaft of pivot pier 1 N. The shafts of the other four river piers are rectangular and solid. Drawings of pier 1 S are reproduced in Figs. 6 to 9, opposite. The right-hand sides of Figs. 6 and 7 show the completed pier, the left-hand sides illustrating the sinking arrangements.

Pivot Piers.

The building of the pivot piers probably constituted the most difficult and interesting operation in the construction of the bridge. As the deepest caissons had to sink to a depth of 110 ft., or more, before they reached material sufficiently solid to support them, it was necessary that they should be capable of floating until they reached a firm bottom. As a concrete caisson with outer walls 4 ft. thick and internal 3-ft. cross walls could not fulfil this condition, it was necessary to construct steel caissons inside which the concrete caissons were built up after sinking. The steel caissons, 110 ft. high, had outer skins of $\frac{3}{8}$-in. plate and were reinforced internally with diaphragms and struts. Their construction is shown in the left-hand sides of Figs. 6 to 9. They were built by the Newport News Shipbuilding and Drydock Company in one of their graving docks at Newport News and were towed to site. The draft during this operation was about 34 ft., the caissons carrying a ballast of concrete. A view of one of the caissons in tow is reproduced in Fig. 12, on page 740. The length of tow was about 40 miles.

To place and hold a caisson in correct position in the river for sinking, a temporary containing dock was built. The normal speed of the river current is about three miles an hour, but at times of heavy discharge this figure may be doubled; also the possibility of strong winds acting on the tall structure had to be allowed for. The temporary dock was formed by four towers, built up of steel tubing, one at each face of the caisson. Each tower was 20 ft. square and 112 ft. high and weighed 45 tons. It was made up of four 14-in. seamless steel tubes, one at each corner, connected together with 8 in. and 10-in. tubular bracings. One of the towers, handled by two floating cranes, was accurately positioned by triangulation from the shore, and was then spudded to the river bed by 10¾ in. diameter tubes, 150 ft. long, driven through the tower legs. The spuds were then bolted to the tops of the legs. An early stage in the erection of the dock is shown in Fig. 13, on Plate XXII.

When the first tower was in position, the next two were located from it and spudded in position. The three towers were then connected by a steel yoke and the caisson was floated into position in the open-sided chamber thus formed. It was tied to prevent it moving out and the fourth tower was spudded in position. There were rubbing strips on the towers, set at a clearance of 9 in. from the sides of the caisson, and by placing shims between the strips and the caisson, it was possible to locate the latter in the exact position for sinking.

Construction of Caissons.

As shown in Figs. 6 and 7, the steel caissons were provided with cutting edges at the bottom and a series of six dredging wells. The largest caissons, shown in these figures, had wells 12 ft. in diameter; for the smaller caissons the diameter was 9½ ft. Dredging and concrete placing were carried out by floating cranes with 125-ft. jibs. Concrete was mixed in a yard set up on the Yorktown shore and transported to the piers in barges, each carrying four 2-cub. yd. concrete buckets. The yoke forming the upper part of the temporary docks by which the caissons were located in position, served as working platforms carrying hoppers into which the concrete from the barges was charged. The largest floating caisson carried about 1,500 tons of concrete as ballast. To sink it to the river bed, concrete was supplied through the compartments outside the dredging wells, which were capped during this stage of the operation and were supplied with compressed air. The cross bracing in the outer compartments restricted the space through which the concrete buckets could be lowered, clearances amounting to only a few inches. During rough weather the swaying of the floating cranes was so considerable that it was found impossible to thread the buckets past the bracing until guides had been installed. These were flared out at the top to facilitate entry of the buckets. The concrete was delivered to a 3-cub. yard receiving hopper, on a temporary platform, from which it was delivered by small hand-operated trucks.

When the caisson had settled on the bottom of the river the caps were removed from the dredging

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Fig. 6. SECTION A-A.

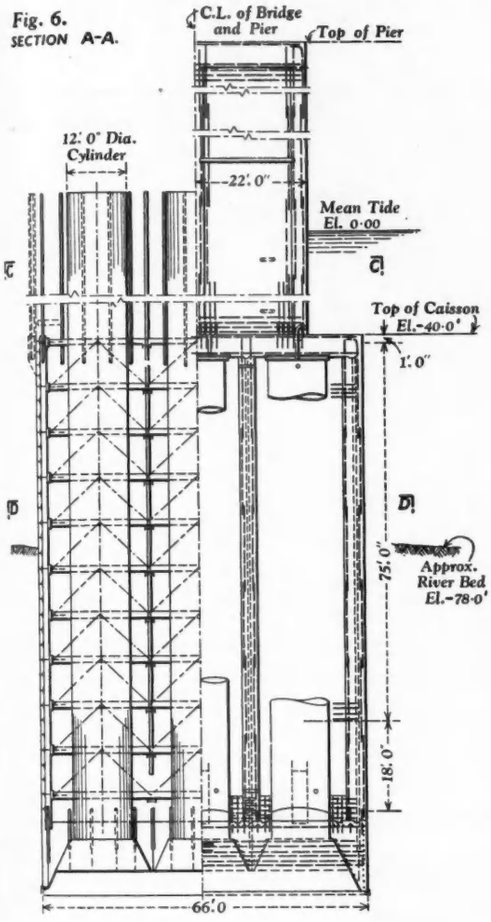

Fig. 7. SECTION B-B.

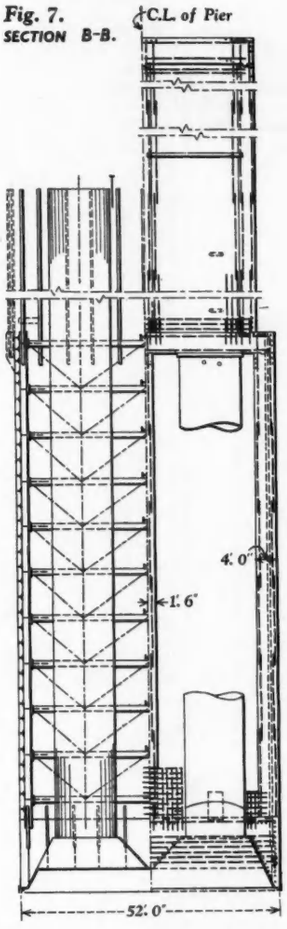

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Fig. 8. SECTION C-C.

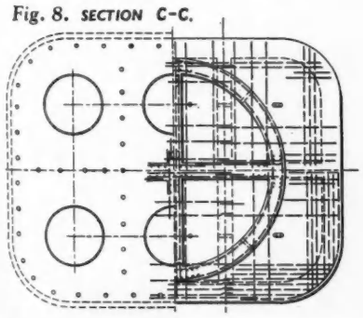
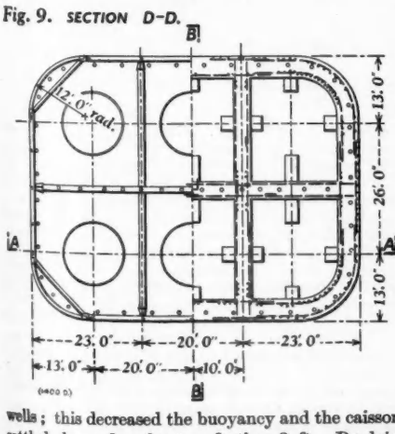


Fig. 9. SECTION D-D.



wells; this decreased the buoyancy and the caissons settled down for about a further 3 ft. Dredging was begun and as the caisson gradually sank the working platform in the outer wall was moved upward from time to time. The cross bracing was embedded in the concrete walls and bulkheads, and steel reinforcement was placed, as shown in Figs. 6 and 7. When such a depth had been reached that the freeboard was about 10 ft., the outer walls of the steel caisson were extended upward so that work could continue in the dry. When the permanent caisson outer and cross walls had been completed, a 14-ft. deep seal was formed at the bottom of the dredging wells, the concrete being laid by tremie, and after the wells had been pumped out a 3-ft. thick concrete cap was laid on this seal. Finally, a load-distributing slab, 4 ft. thick, was laid on the top of the concrete caisson and on this the pier extension, rising 100 ft. above the top of the caisson, was constructed. The piers were built by the Massman Construction Company and the Kansas City Bridge Company, both of Kansas City, under a joint contract.

Bridge Superstructure.

The superstructure of the bridge was built by the American Bridge Division of the United States Steel Corporation. The types of the various spans of which the total length of 3,750 ft. is made up have already been referred to. The fixed spans are of normal types and do not require detail comment, but the supporting arrangements of the 500-ft. swing spans embody special features of interest. All spans were built up on heavy barges, towed to site at high tide, and lowered on to the piers as the water level fell, the operation being speeded up by pumping water ballast into the barges. The floating of the last fixed-span into position is illustrated in Fig. 14, on Plate XXII. Each of the swing spans weighs about 1,200 tons, and when in motion, or free to rotate, is supported on a single centre pivot, lateral stability being provided by four pairs of 28-in. diameter balance wheels running on a 34-ft. 6-in. diameter steel track, on the top of the pier. A plan view of the framing of the span at the pivot is given in Fig. 10, on page 740, and a cross-section showing the balance wheels and pivot in Fig. 11. The four pairs of balance wheels are set 90 deg. apart. The span is moved by three 20-h.p. electric motors acting through gear trains and driving pinions which engage a 36-ft. 6-in. diameter circular rack bolted to the top of the pier. The arrangement of the drive is shown in Fig. 11, and the positions of the three gears on the span in Fig. 10. Electrically-operated brakes are provided which are capable of stopping and holding the span in any position. In case of necessity, any two of the motors can operate the span. The centre pivot, which has a bronze bearing riding on a steel face, is also shown in Fig. 11.

When the spans are in the closed position, permitting traffic to pass, they are locked at the piers by wedges driven home by electric motors. The positions of these wedges are indicated in Fig. 10. At the shore end of each swing span, and also at the centre point of the bridge, where the two spans meet, locking bars are provided. The conditions with which these locks have to comply are severe. Normal operating clearances and inevitable wear during years of operation will cause the spans to tip slightly on the pivot piers, causing some misalignment between the locking bars and the sockets with which they engage. There will also be some warping of both the moving and fixed spans owing to uneven temperature effects and even wind pressure. To meet these conditions, the locking arrangements must be powerful enough slightly to distort the spans to bring them into the correct closed positions. The locking bars are accordingly heavy I-shaped alloy-steel castings 18 in. deep, 10 in. wide and 18 ft. long. The travel is 4 ft. 3 in. The bars are provided with racks and are forced into place by means of electric motors acting through reduction gears. Separate detachable manganese-steel wearing plates have been provided at points of contact.

Electric Power.

Power for the operation of the bridge is supplied from a transformer substation situated in the upper part of pivot pier S 1; it is connected to the mains of the Virginia Electric and Power Company by a high-tension submarine cable. Low-tension connections from this substation are carried to all the bridge motors, by underwater cables where necessary. A stand-by power supply is provided by a petrol-engine generating set, also located in pier S 1. Normally, all movements of the bridge are controlled by a single operator situated in a control house carried on a structural framework above pier S 1. It can be seen in the general view of the bridge given in Fig. 1, and is shown in Figs. 15 and 16, on Plate XXII. The movement of vehicles on to the bridge is controlled by warning gates, one at each end. In addition, there are vertical-lift barrier gates situated above the piers on each side of the pivot piers. One of the barrier gates is illustrated in Fig. 16, on Plate XXII. As the control house is more than 1,000 ft. from the warning gates, in conditions of poor visibility the operator in that house may not be able to see traffic movements clearly at the bridge entrances. To deal with this situation, and also with conditions in which the volume of traffic is unusually heavy, two sub-control cabins are provided below the roadway deck and near to the barrier gates. Operators in these cabins, who are in communication with the operator in the main control house by

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Fig. 10.

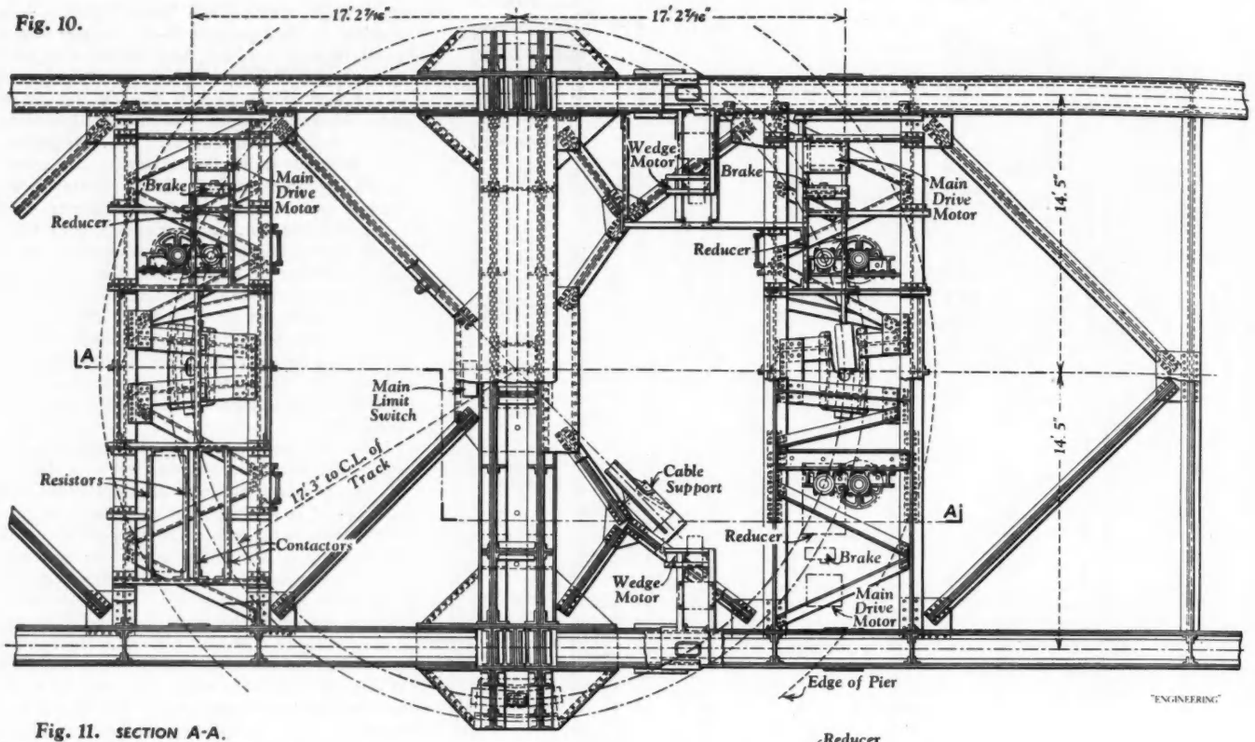
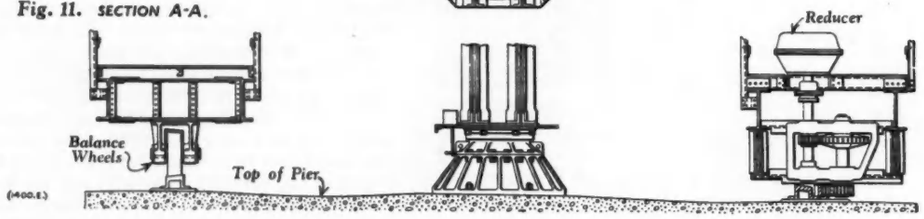


Fig. 11. SECTION A-A.



telephone and a buzzer system, can control the traffic lights and the gates.

The controls of the whole of the operations which precede the opening of the swing spans for shipping to pass are interlocked and the sequence cannot be altered. The road-traffic lights and warning gongs are first switched on, the warning gates are then closed, followed by the barrier gates. The span locks are then withdrawn, and, after them, the centre wedges. The spans may then be opened. To open the bridge for road traffic, the reverse sequence is followed, but an additional safety precaution is introduced. In the event of any of the four gates not moving to the full-open position, the red flashing lights with which all the gates are equipped are turned on. Other safety devices include limit switches on motors to operate their brakes when the mechanism they control has reached the end of its proper travel. In the case of the motors operating the spans, the limit switches automatically change them over to slow speed, if the operator fails to do so, as the spans approach the end of their travel. Air buffers are fitted to cushion the last few feet of travel.

The bridge rises on a 4·5 per cent. grade to the centre point, at which the roadway is about 115 ft. above water level. The 26-ft. wide roadway accommodates two-lane traffic. The kerbs are 10 in. high and 2 ft. 6 in. wide. The bridge is not open to pedestrians, the kerbs serving only as an emergency sidewalk. A cross-river 'bus service is operated. The bridge deck is of reinforced concrete on the fixed spans; this may be seen in Fig. 15, which shows the kerbs under construction. On the swing spans, the roadway is of 5-in. deep steel open grating and the kerbs are built up of steel plate. The roadway on one of the swing spans is shown in Fig 16. The railings, built up of rolled sections and bars, are 3 ft. 4 in. high. The bridge, the cost of which, excluding approaches, was approximately 7,200,000 dollars, was designed by Messrs. Parsons, Brinkerhoff, Hall and Macdonald, of New York, consulting engineers to the Virginia State Highways Department.

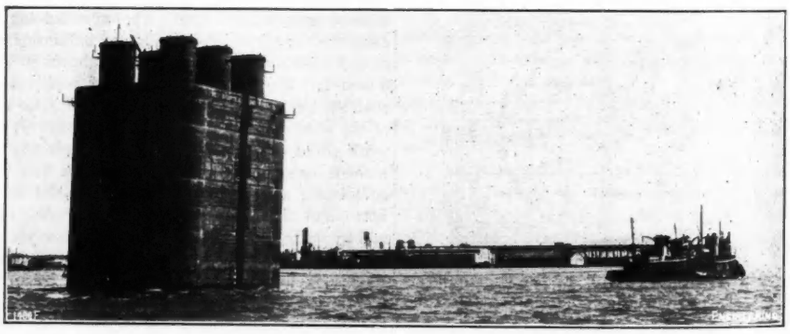


FIG. 12. CAISSON UNDER TOW.

DOUBLE-DUCT RISING-MAIN SYSTEM FOR ELECTRICAL INSTALLATIONS.—The General Electric Co., Ltd., Kingsway, London, W.C.2, have recently improved their totally-enclosed rising-main system in which solid copper bars are run from the supply intake to distribution boards on the upper floors. The improvement consists of two separate wiring ducts, one on each side of the rising main, which are contained in a steel casing. These ducts carry the sub-circuit cables, which are run from plug-in distribution fuse boards to points where lateral conduits are connected with the floor trunking. Each distribution board contains a row of fuse units mounted on an insulating panel and connected to a copper 'bus-bar through laminated pressure contacts of the brush type. These contacts have a surface area of 2 sq. in. and line up with blocks on the rising mains, guide pins being provided to ensure correct alignment when the holding wing nuts are tightened. Slots are provided at each side of the boards, through which the cables can be passed into the lateral distribution channel ways. Each board is designed to supply the floor on which it is situated or the one above or below. All the sub-circuit cables, which are accommodated in wiring ducts, can pass in an upward or downward direction. Each board can be sealed and used as the supply authorities' cut-out, a feature of importance when the rising main is used to supply blocks of flats or individual offices. They are also arranged to facilitate load balancing.

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(*For Description, see Page* 737.)

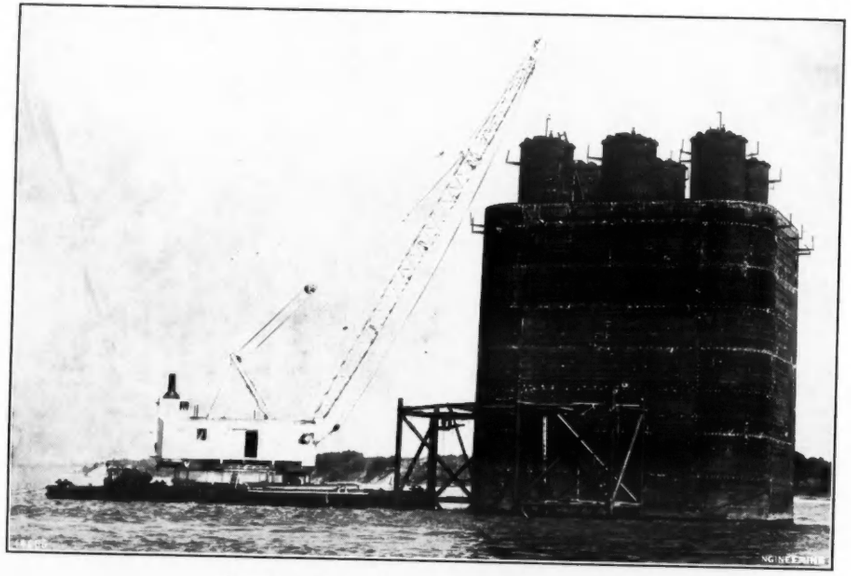


FIG. 13. TOWER DOCK UNDER CONSTRUCTION.

FIG. 14. SPAN BEING FLOATED INTO POSITION.

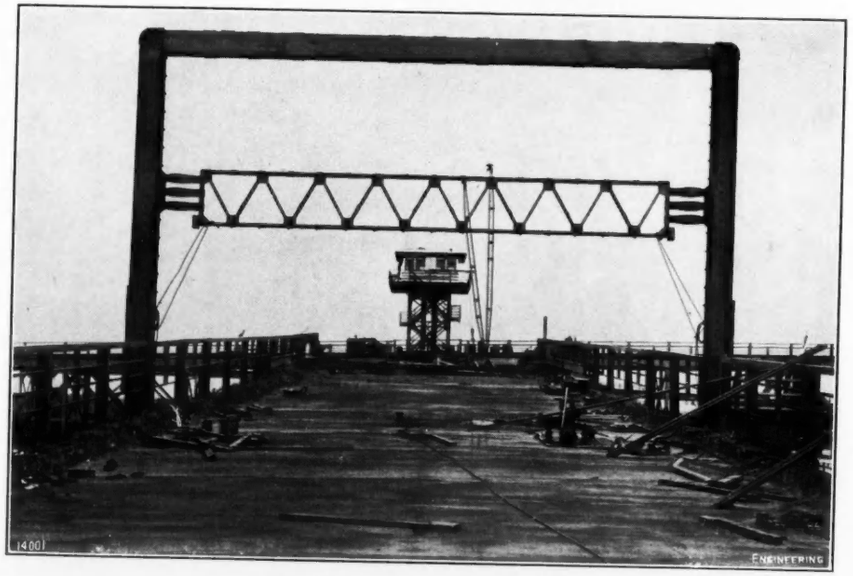


FIG. 15. VIEW ALONG FIXED SPAN.

FIG. 16. VIEW ALONG SWING SPAN.

THE USE OF MODELS IN STRUCTURAL ANALYSIS.

By J. WRIGHT, B.Sc.

(*Concluded from page* 712.)

Internal Moments in a Frame.—The method of determining the influence line for an internal moment in a member of a framed structure is to apply an angular displacement at the point under consideration, and the resultant elastic curve of deformation is the influence line for the moment at that point. Fig. 11 illustrates the influence line for M_c of the continuous beam ABCDE. Two methods are described, as both being suitable to the practical designer. They are: modified Begg's method, and the M.I.T. moment deformeter.

Fig. 11.

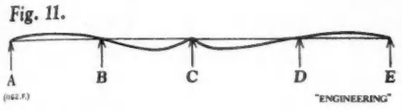
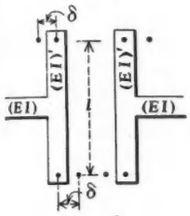


Fig. 12. (*a*)



(*b*)

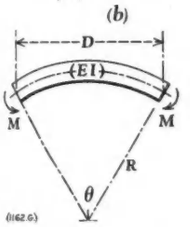
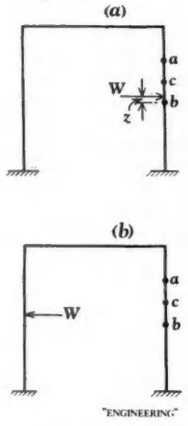


Fig. 14.



Modified Begg's Method.—This method necessitates the cutting of the member at the point at which the moment is required and the application of an angular displacement at that point. There are many methods of accomplishing this, and the following method is suggested. A portion of the beam of length D is removed and replaced by two arms of flexural rigidity (EI)′, as shown in Fig. 12(*a*). These arms are connected by a plate fixed by pins to *a*, *b*, *c*, and *d*. The flexural properties of these arms must clearly represent those of the piece of beam they replace (Fig. 12(*b*)). In order to determine the condition for flexural similarity, suppose that a moment $M = Fl$ is applied to both conditions.

The rotation of the arms will be $\frac{4\,\delta}{l}$ and the rotation of the beam of length D will be $\theta = \frac{D}{R} = \frac{M\,D}{(E\,I)} = \frac{F\,l\,D}{(E\,I)}$. These rotations must be equal, thus

$$\frac{4\,\delta}{l} = \frac{F\,l\,D}{(E\,I)}. \quad . \quad . \quad (27)$$

To simplify this expression, the value of D can be computed by considering the deflection of a cantilever of length $\frac{l}{2}$, subject to a point load F at the free end, and then

$$\delta = \frac{F}{3\,(E\,I)'}\left(\frac{l}{2}\right)^3 = \frac{F\,l^3}{24\,(E\,I)'}. \quad . \quad (28)$$

Substituting this value of δ in equation (27) the following expression is obtained

$$\frac{4}{l}\,\frac{F\,l^3}{24\,(E\,I)'} = \frac{F\,l\,D}{(E\,I)},$$

or

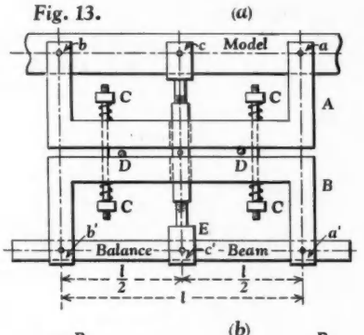
$$\frac{l}{6\,I'} = \frac{D}{I}. \quad . \quad . \quad . \quad (29)$$

if the arms are of the same material as the beam as is true when the arms are an integral part of the model.

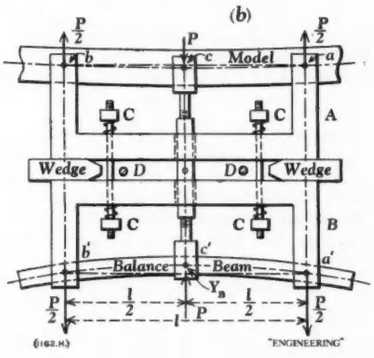
Equation (29) thus gives the condition which must be satisfied by the dimensions of the joint for applying an angular displacement within a member. A deflection plate can be used for applying the rotations in both positive and negative senses.

M.I.T. Moment Deformeter.—The original M.I.T. moment deformeter was developed by Professor J. B. Wilbur, of the Massachusetts Institute of Technology. The deformeter applies to a model a distortion such that the elastic line of the model outside the part

Fig. 13. (*a*)



(*b*)



on which the instrument is fixed assumes the shape of the influence line for bending moment at the point represented by the centre point of the instrument. In contrast with the conditions of the method described previously, there is no need to cut the model at the point for which the influence line for bending moments is required. On the other hand, it can only be used for points in the structure which are farther away from corners and supports than half the length of the apparatus.

The instrument consists of two U-shaped frames A and B (see Fig. 13 (*a*)) which are separated by two plugs D and held together by springs C. Through a horizontal hole in the frame an adjustable connector is loosely passed. Frame A is fixed to the model with a pair of pins *a* and *b* which pass through holes in the frame and in the model. To the frame B a so-called "balance beam" is fixed (the purpose of which will be explained later) in points *a*′ and *b*′ with a similar pair of pins. Point *c* on the model is connected to *c*′ on the balance beam by an adjustable connector which has holes at each end through which pins are passed to connect it with the model and the balance beam. When two wedges of equal size are inserted between frames A and B, the distances *a a*′ and *b b*′ increase by the same amount while the connector, which must be previously tightened so that there is no loose movement, holds points *c* and *c*′ at their original separation. Both the model and balance beam distort as shown in Fig. 13 (*b*). The insertion of the wedges produces the forces P at the points *c* and *c*′ and $\frac{P}{2}$ at *a*, *a*′, *b* and *b*′.

The balance beam is introduced in order to measure the magnitude of the force P and is constructed as a simply-supported beam. If the deflection Y_B (see Fig. 13 (*b*)) is measured, the force P can be found from the formula for the deflection of a simple beam loaded at the centre. If the balance beam is made from the same material as the model, that is, if it has the same value of E, and when its inertia is I_B, the necessary value of the force is

$$P = \frac{48\,E\,I_B\,Y_B}{L^3}. \quad . \quad . \quad (30)$$

There are two conditions of loading to be considered, i.e., if the load is applied within the instrument case 1, and if the load is applied outside the instrument case 2.

Load Applied Within the Instrument.—Wilbur showed that in this case the value of the moment at *c* caused by a unit load at *x*, is given by the expression

$$m_c = \frac{8E\,I\,Y_x}{P\,L^2} + \frac{2}{3}\,\frac{z^3}{L^2}, \quad . \quad (31)$$

where *z* is measured from the point *a*, as shown in Fig. 14 (*a*). Substituting the value of P from equation (30) in this expression, then

$$m_c = \frac{L}{6}\left\{\frac{I}{I_B}\,\frac{Y_x}{Y_B} + \frac{4\,z^3}{L^3}\right\}. \quad . \quad (32)$$

Load Applied Outside the Instrument.—Wilbur showed that in this case (see Fig. 14(*b*))

$$m_c = \frac{8\,E\,I\,Y_x}{P\,L^2}, \quad . \quad . \quad (33)$$

and substituting for the value of P from equation (30) into this expression the value of m_c is given by

$$m_c = \frac{L}{6}\,\frac{I}{I_B}\,\frac{Y_x}{Y_B}. \quad . \quad . \quad (34)$$

The value of I in these equations is the value of I for point *c*.

In the derivations of equations (32) and (34) it was assumed that the second moment of area between *a* and *b* is constant. If the model is large in comparison with the length of the instrument L, it is possible to assume that, even with non-prismatic members, there is no variation and the instrument can be used to obtain approximate values of influence lines. It should be noticed that only the part of the structure between the points to which the apparatus is fixed comes into account, when considering varying moments of inertia. As explained previously, equations (32) and (34) must be multiplied by the scale of length *m* of the model to develop the moments in the actual structure.

PRINCIPLES AND TECHNIQUE OF DIRECT METHOD.

As shown in the section dealing with model scales, the deflected form of a model is similar to the deflection of the prototype. This concept is made use of in the direct method of model analysis, for, when a model is loaded in a similar manner to the prototype, the deflected shape of the model is similar to the deflected shape of the prototype, that is, the deflections and angular displacement of the joints of a model are directly proportional to those of the structure. The fact that a model is displaced by actual loading rules out most of the direct methods as a drawing board technique. However, this difficulty can be overcome by using a compensating balance. The principle of this balance will be described later.

There are many direct methods of model analysis, but only two methods are described here, as, in the author's opinion, they are the only methods adaptable to the requirements of the practical designer.

Moment Indicator.—The moment indicator, like the moment deformeter, was developed at the

Massachusetts Institute of Technology, and is a useful device for determing the moments at two points on a member which is initially straight, of constant section and has no external loading between the points. Considering such a member of which the ends A and B, are a distance l apart, then if θ_A and θ_B are the changes in slope of the tangent to the elastic curve at the points A and B respectively, they are related as follows:

$$M_A = \frac{2EI}{l}(2\theta_A + \theta_B), \quad . \quad (35a)$$

and

$$M_B = \frac{2EI}{l}(2\theta_B + \theta_A), \quad . \quad (35b)$$

where M_A is the moment at A and M_B is the moment at B. These equations are well known as the Manderla-Winkler* equations. The moments are considered positive when acting clockwise, and the values of θ are considered positive when measured clockwise with reference to the chord AB.

Suppose two arms are fixed to the points A and B, as shown in Fig. 15(*a*). When the model is loaded outside the points A and B, the points will rotate, as shown in Fig. 15(*b*). As the rotations are considered to be small, the angles θ_A and θ_B can be measured by the relative movements of the targets *a*, *b*, *a'* and *b'*. If Δ_A and Δ_B are the relative movements of the targets, being positive when the targets move apart, then

$$\Delta_A = \frac{2l}{3}\theta_A + \frac{l}{3}\theta_B = \frac{l}{3}(2\theta_A + \theta_B), \quad (36a)$$

and

$$\Delta_B = \frac{2l}{3}\theta_B + \frac{l}{3}\theta_A = \frac{l}{3}(2\theta_B + \theta_A). \quad (36b)$$

Substituting for $(2\theta_A + \theta_B)$ and $(2\theta_B + \theta_A)$ in equation (35), the following equations for the end moments are obtained:

$$M_A = \frac{6EI}{l^2}\Delta_A. \quad . \quad . \quad (37a)$$

$$M_B = \frac{6EI}{l^2}\Delta_B. \quad . \quad . \quad (37b)$$

It will be seen that the moments depend on E, a property of the material not always known with accuracy owing to creep. Relative values can, however, be obtained and can often be converted into absolute values by the laws of static equilibrium. Such a case is the problem of sway in rigid frames. Consider the fixed-base portal, as shown in Fig. 16. Arms attached to the points A, B, C and D would yield relative values of the moments in the base and top of each column. For static equilibrium the following equation must be satisfied.

$$\Sigma H = 0 \quad \text{or}$$

$$M_{AB} + M_{BA} + M_{DC} + M_{CD} + P h = 0$$

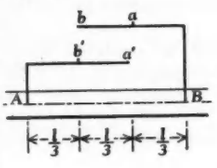
and thus, by direct proportion, the relative values can be converted into absolute results.

Compensating Balance.—When applying a fixed load to a model of celluloid, it is necessary to overcome the creep phenomena mentioned earlier. This can be accomplished by the use of a celluloid spring balance. The theory underlying the spring balance can be explained by referring to Fig. 17, where the cantilever is assumed to be the model. Assume further the point T moves through a distance Δ to T'; then the force in the steel toggles QR and ST (which are considered infinitely stiff in comparison to the model and balance) at any instant is P. This tension, which varies with time, causes the target on the balance to move a distance Δ_R, and the point Q on the cantilever to move a distance Δ_Q. If the cantilever and spring balance are cut from the same piece of celluloid, the deflections Δ_R and

* Calculation of Secondary Stresses which Occur in Simple Trusses as a Consequence of Rigid Joints, *Allgemeine Bauzeitung*, page 34 (1880).

USE OF MODELS IN STRUCTURAL ANALYSIS.

Fig. 15. (*a*)



(*b*)

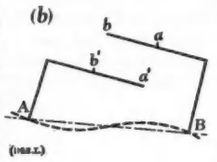


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Fig. 16.

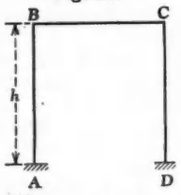
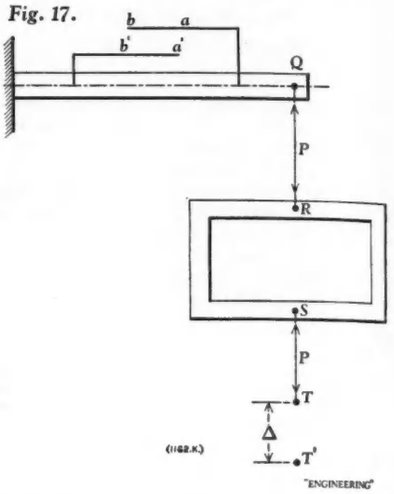


Fig. 17.



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"ENGINEERING"

Fig. 18.

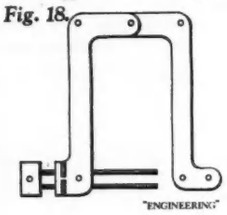

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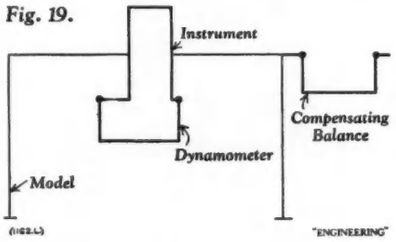
Fig. 19.



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"ENGINEERING"

Δ_Q may be expressed as

$$\Delta_R = C_R \frac{P}{E}, \quad . \quad . \quad (38a)$$

and

$$\Delta_Q = C_Q \frac{P}{E}, \quad . \quad . \quad (38b)$$

where C_R and C_Q are constants, which depend on the dimensions of the spring balance and cantilever, respectively. The deflection of the point T is then

$$\Delta = \Delta_R + \Delta_Q = \frac{P}{E}(C_R + C_Q),$$

or

$$\frac{P}{E} = \frac{\Delta}{(C_R + C_Q)} = \text{constant}. \quad . \quad (39)$$

Thus, from equations (38) and (39), it can be seen that Δ_R and Δ_Q are constants, and independent of time, which means that a fixed deflection applied through this system will produce a fixed deflection of the cantilever. The compensating balance is useful in conjunction with the moment indicator. When taking readings of the moment indicator targets the deflection of the spring balance Δ_R should also be read. The instantaneous value of E from equation (38*a*) is

$$E = \frac{C_R}{\Delta_R} P, \quad . \quad . \quad (40)$$

and substituting this value in equation (37), then

$$M_A = \frac{6IC_R}{l^2}\frac{\Delta_A}{\Delta_R} P, \quad . \quad (41a)$$

$$M_B = \frac{6IC_R}{l^2}\frac{\Delta_B}{\Delta_R} P. \quad . \quad (41b)$$

Hence absolute moments can be obtained. The value of C_R can be obtained by calculation or calibration.

Dynamometer.—The principle of the dynamometer was conceived by Mr. T. M. Charlton and published in *Civil Engineering*.* The particular instrument, which will be described later, was designed and made by the author. The purpose of the dynamometer is to determine the direct force, shearing force and moment at a point in a member. The model must be made with a joint, as previously described, at the point under consideration in the model, and the instrument, shown in Fig. 18, must be capable of fitting over the four holes. A dynamometer consisting essentially of a U-shaped frame is fitted to the legs of the instrument, and loading is effected through a compensating balance. The set-up of the model, instrument, dynamometer and compensating balance is shown diagrammatically in Fig. 19. The dynamometer is adjusted before the model is loaded, so that the joint bars are parallel and the model and dynamometer are unstrained. The model is then loaded by applying a fixed deflection to the compensating balance, and the dynamometer is again adjusted until the joint bars are parallel. The deflection of the dynamometer is then noted and the procedure repeated with the instrument reversed. Thus, the force at both ends of the vertical bar necessary to hold the joint in position under load is measured.

If the two dynamometer readings are Y_{D1} and Y_{D2}, they can be expressed as

$$\left.\begin{aligned} Y_{D1} &= K_D \frac{F_{m1}}{E_m}, \\ \text{and} \quad Y_{D2} &= K_D \frac{F_{m2}}{E_m}, \end{aligned}\right\} \quad (42)$$

where F_{m1} and F_{m2} are the respective forces at the centre lines of the opposite pairs of joint pins and K_D is the dynamometer constant, depending upon its geometrical properties. The values of Y_{D1} and Y_{D2} do not vary with creep when loading is applied through a compensating balance, provided that the dynamometer and model are unstrained before the deflection is applied to the former. Then

$$\left.\begin{aligned} F_{m1} &= \frac{E_m Y_{D1}}{K_D}, \\ \text{and} \quad F_{m2} &= \frac{E_m Y_{D2}}{K_D}. \end{aligned}\right\} \quad (43)$$

F_{m1} and F_{m2} can be expressed in terms of the moment M_m and axial force T_m in the model member.

$$\left.\begin{aligned} F_{m1} &= \frac{M_m}{d_m} + \frac{T_m}{2}, \\ F_{m2} &= \frac{M_m}{d_m} - \frac{T_m}{2}, \end{aligned}\right\} \quad (44)$$

where d_m is the distance between the centre lines of the pin-holes of the joint, i.e., the distance between the lines of action of F_{m1} and F_{m2}.

* *Civil Eng. and Public Works Review*, vol. 48, pages 51-53, January, 1953.

POWER JETS' GAS-TURBINE PATENTS.

Fig. 1.

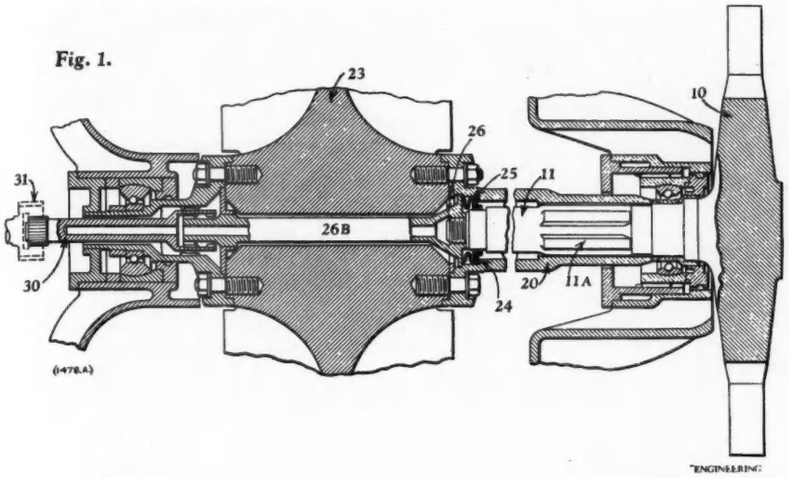
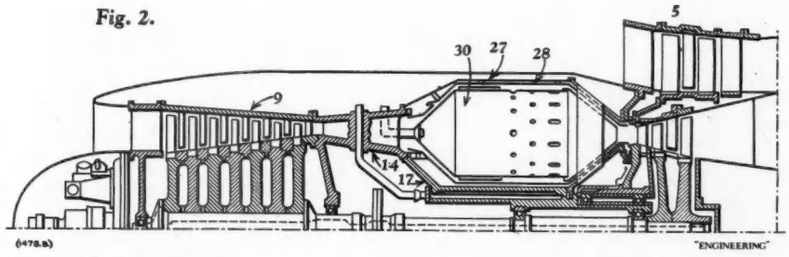


Fig. 2.



From equations (43) and (44)

$$\left.\begin{aligned} M_m &= \frac{E_m\, d_m}{2\, K_D}\,(Y_{D1} + Y_{D2}) \\ \text{and} \\ T_m &= \frac{E_m}{K_D}\,(Y_{D1} - Y_{D2}). \end{aligned}\right\} \quad (45)$$

To convert these values to the prototype, a different constant, K'_D must be substituted for K_D, md_m for d_m, mY_{D1} and mY_{D2} for Y_{D1} and Y_{D2}, and then

$$\left.\begin{aligned} M_p &= \frac{E_p\, m^2\, d_m}{2\, K'_D}\,(Y_{D1} + Y_{D2}), \\ T_p &= \frac{E_p\, m}{K'_D}\,(Y_{D1} - Y_{D2}). \end{aligned}\right\} \quad (46)$$

The force applied to the prototype which produce this moment and force is

$$F_p = \frac{E_p\, m\, Y_B}{K'_B}, \quad . \quad . \quad (47)$$

where the suffixes refer to the compensating balance and K'_B is a modified balance constant. Substituting for E_p from equation (47) into equation (46)

$$\left.\begin{aligned} M_p &= F_p\,\frac{K'_B}{K'_D}\,\frac{m\, d_m}{2}\left(\frac{Y_{D1} + Y_{D2}}{Y_B}\right) \\ \text{and} \\ T_p &= F_p\,\frac{K'_B}{K'_D}\left(\frac{Y_{D1} - Y_{D2}}{Y_B}\right). \end{aligned}\right\} \quad (48)$$

Equation (48) gives the value of the moment and direct force in the prototype for any load F_p. As $\frac{K'_B}{K'_D}$ will be identical with $\frac{K_B}{K_D}$, then

$$\left.\begin{aligned} M_p &= F_p\,\frac{K_B}{K_D}\,\frac{m\, d_m}{2}\left(\frac{Y_{D1} + Y_{D2}}{Y_B}\right) \\ \text{and} \\ T_p &= F_p\,\frac{K_B}{K_D}\left(\frac{Y_{D1} - Y_{D1}}{Y_B}\right). \end{aligned}\right\} \quad (49)$$

In most instances, the dynamometer and the compensating balance can be constructed so that they are identical in shape and dimensions. In this case, the ratio $\frac{K_B}{K_D}$ becomes unity and equation (49) becomes

$$\left.\begin{aligned} M_p &= F_p\,\frac{m\, d_m}{2}\left(\frac{Y_{D1} + Y_{D2}}{Y_B}\right), \\ \text{and} \\ T_p &= F_p\left(\frac{Y_{D1} - Y_{D2}}{Y_B}\right). \end{aligned}\right\} \quad (50)$$

thus eliminating the need to calibrate either the dynamometer or the balance beam.

In conclusion, the author wishes to acknowledge his indebtedness to Messrs. Merz and McLellan for permission to publish this article, and to Professor W. Fisher Cassie and Mr. T. M. Charlton for guidance and assistance.

CAST-IRON HEATING PIPES FOR OIL TANKERS: ADDENDUM.—We have been advised by Jennings Winch & Foundry Co., Ltd., Borough-road, Sunderland, that they manufacture cast-iron heating coils for oil tankers, and have, in fact, been doing so for a considerable time. We publish this information as, in an article on page 601 of the issue of May 8, the impression was unintentionally given that work of this kind was undertaken exclusively by Colvin-Smith, Ltd., Team Valley, Gateshead-on-Tyne.

THE LATE MR. A. W. HALL.—We regret to record the death of Mr. Alfred Weedon Hall, which occurred on Friday, May 22 at the age of 60. He joined Marconi's Wireless Telegraph Co., Ltd., in 1913 as a test-room assistant and, after serving in the Royal Naval Volunteer Reserve during the 1914-18 war, became a member of the staff of Mr. C. S. Franklin, who was then working on the spaced-frame system of radio reception. Subsequently, he was in charge of one end of the experimental duplex radio telephone link between Birmingham and Hendon, while in 1922 he assisted Mr. Franklin on the short-wave transmission from Poldhu to the yacht Elettra. During this period, the first beam transmitters were designed and the advantages of directional aerials established. After a short time in the United States, Mr. Hall was engaged with the Marconi Company in designing short-wave transmitters until, in 1943, he was lent to the Admiralty for research work. He returned to the company in 1946 and was attached first to the engineer-in-chief's department and then to the Technical Information Division.

POWER JETS' GAS-TURBINE PATENTS—IX.*

GENERAL CONSTRUCTIONAL FEATURES OF GAS-TURBINE PLANT.

THE four preceding sections have been concerned with patents relating to the three main components which are common to aero and industrial gas-turbines, namely, compressors, combustion systems and turbines. None of those sections afforded a proper place for review of patents relating to constructional expedients employed in the assembly together of the respective components to provide the complete plant; the present section reviews some of the more interesting examples of Power Jets' patents which relate to such expedients.

The first of these patents, No. 595,669, concerns a rotor assembly known, in Power Jets terminology, as the "Bone Shaft" and which, while being rigid and robust, is capable of easy assembly and dismantling. The construction is particularly suitable for cases in which two rotor elements (such as the compressor and compressor-driving turbine of a gas-turbine plant, two compressors or the turbine and impeller of a turbo-supercharger) are required to be coaxially united in torque-transmitting relation and it is desirable, owing to the nature of the installation, that the one element should be detachable by means of access to the far side of the other element. One example of a "Bone Shaft" construction is illustrated by Fig. 1, which represents a section through the impeller 23 of a centrifugal compressor and the shafting by which it is drivingly connected to an overhung turbine wheel 10. As shown, the turbine wheel is formed integrally with a stub-shaft 11, which projects into and is in splined connection (as at 11A) with a hollow quill shaft 20, which is rigidly secured to the face of the impeller adjacent to the turbine. The end of the stub-shaft is threaded for engagement with a "nut" 26 formed on the end of a "nut-shaft" 26B, which passes through an axial bore in the impeller; on assembly, the nut 26 is screwed up to draw the turbine wheel and impeller together and thereby deform an elastic washer 25 which is provided between the nut and an annular shoulder 24 on the inside of the quill shaft to exert a pre-load upon the stub and quill shafts when in proper assembled relation. When it is required to remove the turbine wheel and its bearing, the connection to the impeller is broken by turning the "nut-shaft" from the front of the compressor; this may conveniently be effected by means of a "spanner-shaft" 30, which has alternative axial positions in one of which it locks the "nut-shaft" against rotation relatively to the impeller and in the other of which it may be used to transmit torque to the former from a tool indicated in dotted lines at 31.

The next patent to be reviewed, No. 624,768, relates to a structural feature of the air-casing of a "cannular" type of combustion system. One object of the invention is to provide an air-casing which, while being capable of taking its share of stress-carrying, is not of a nature such as to impede the removal or replacement of the individual flame tubes or "cans"; to this end, the air-casing is formed as a unitary annular structure of greater diameter than at least one of the major components (i.e. compressor or turbine) and is mounted so as to be capable of being withdrawn over one of such components by an axial movement to expose the flame tubes. The sectional drawing reproduced as Fig. 2 is of a turbo-jet unit with axial-flow compressor 9 and ducted fan augmentor 5, the "cannular" combustion system having a unitary annular air-casing 27; the parts of major interest are illustrated in greater detail by the scrap section shown in Fig. 3, page 744. When it is required to gain access to the flame tubes 30, the air-casing 27 is

* Part VIII appeared on page 706, *ante*.

released and slid forward (after removal of the fuel and lubricating-oil pipes shown projecting from the region of the diffuser) to come to surround the compressor casing. The sheet-metal liner shown at 28, and provided to induce a jacketing flow of relatively cool air around the peripheral portion of the air-casing, carries no stress and can be of light, easily removable construction presenting no obstacle to the inspection and removal of the flame tubes.

Figs. 2 and 3 (and particularly the latter) also serve to illustrate patent No. 624,842, which is likewise concerned with engines having "cannular" combustion systems. The previous patent was concerned with an arrangement wherein the outer wall of an annular air-casing, while having a desirable attribute connected with maintenance work on the combustion system, was capable of taking some part in the carrying of stress; according to the patent at present under review, the inner wall of such an annular air-casing is a stiff member which is structurally integrated with stationary structure of the turbine and compressor and performs the dual function of defining the inner boundary of the air space of the combustion system and of forming a rigid backbone structure which is a major stress-carrying element of the plant. In Fig. 3, the rigid backbone member 17 is shown connected at its forward end to the flange of the diffuser passage 14 and at its rear end to a frusto-conical member 18, which is, in turn, secured to the turbine structure.

Patent No. 625,724 is likewise concerned with the provision of a stress-carrying backbone but, although the drawing here reproduced as Fig. 4 does show a "cannular" combustion system, the application of the invention is not limited to engines of that type. In this case, the invention is further concerned with the structural rigidity of the rear wall of the compressor which, in the case of a centrifugal compressor with uni-lateral entry, may be an annular wall of very considerable superficial area which has to resist the internal compressor pressure and may have also to support a bearing for the shaft. As shown by Fig. 4, the rear wall 11 of the compressor (multi-stage axial flow with a final centrifugal stage) is stiffened by a hollow, box-like structure 14, 15 which is integrated with a tubular backbone member 4; the rear end of the backbone member is rigidly attached to the stationary turbine structure.

The problem may often arise in gas-turbine construction of providing a shaft coupling which is capable not only of transmitting the large torques involved and of accommodating misalignments occurring in assembly or operation but also of resisting axial loads; for example, a coupling between the shafts of a turbine and a compressor may be required to resist the tensional load due to opposing end thrusts exerted by the two components. Patent No. 594,550 is drawn to a coupling which is illustrated in section by Fig. 5. In the arrangement shown, torque from a hollow turbine shaft 3 is transmitted to the rotor 2 of a compressor by way of bolts 10, which clamp together the peripheral portions of two discs 5 and 6; the discs have hub portions which are keyed to a hollow compressor stub-shaft 1 and the turbine shaft 3, respectively. Tensional load is taken by a rod 11 which is secured at one end to an internal flange 13 in the compressor shaft and has, at the other end, a threaded portion 14 which engages a threaded sleeve 15, of which a flange 17 engages an internal flange 16 in the hollow turbine shaft; the threaded connection is provided for the purpose of initial adjustment of the tensional load in the shaft assembly. It is desirable that the relative positions of the two torque-transmitting discs shall not be affected by axial load in the two torque-transmitting shafts and the disc 6 is, for this reason, not located axially in relation to the shaft 3; instead, axial location of the disc is effected by a ferrule 9 having at one end an external flange 8 which engages the hub portion of the disc and at the other end an internal flange 25 which engages a flange 26 on the rod 11. Relative axial movement between the shaft 3 and the disc 6 (e.g., during initial adjustment of tension) is accommodated by the splined engagement between these two members and the rod 11 is made sufficiently flexible to accommodate shaft misalignments permitted by the flexibility of the torque-transmitting discs.

POWER JETS' GAS-TURBINE PATENTS.

Fig. 3.

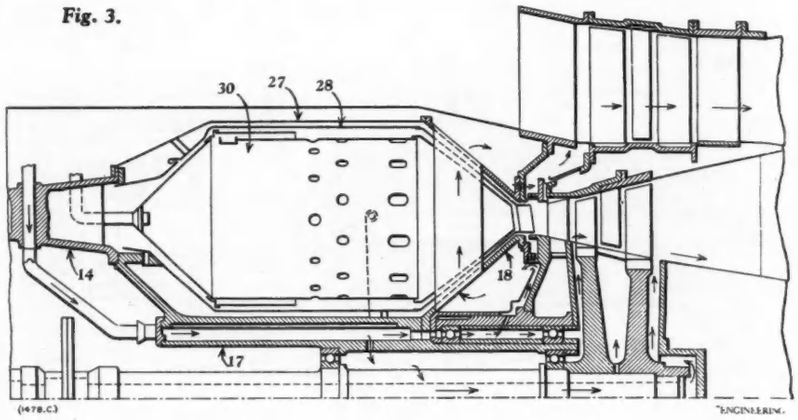


Fig. 4.

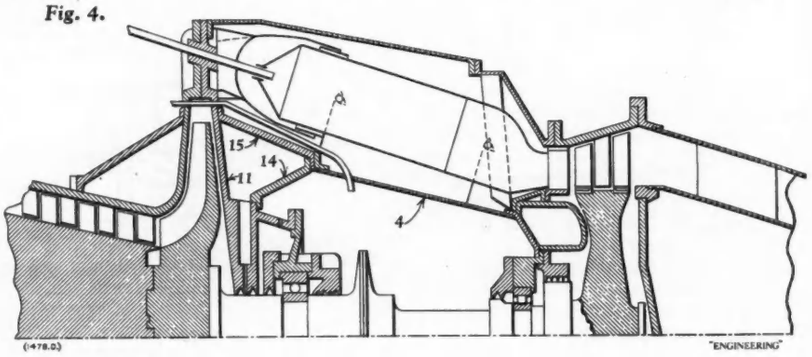
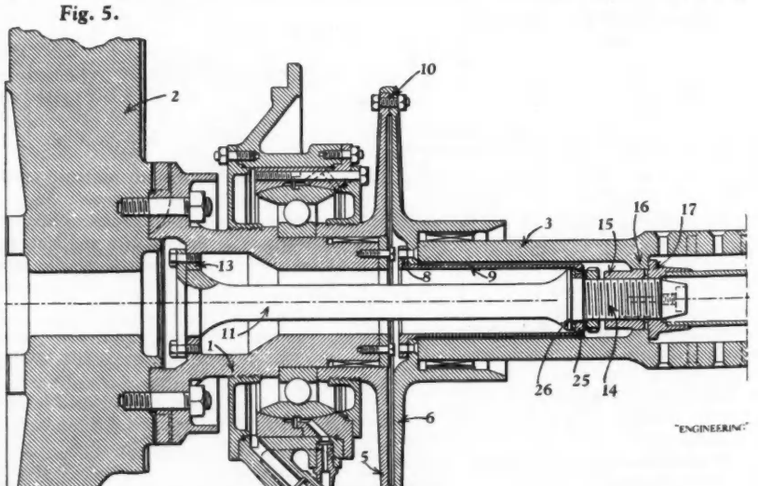


Fig. 5.

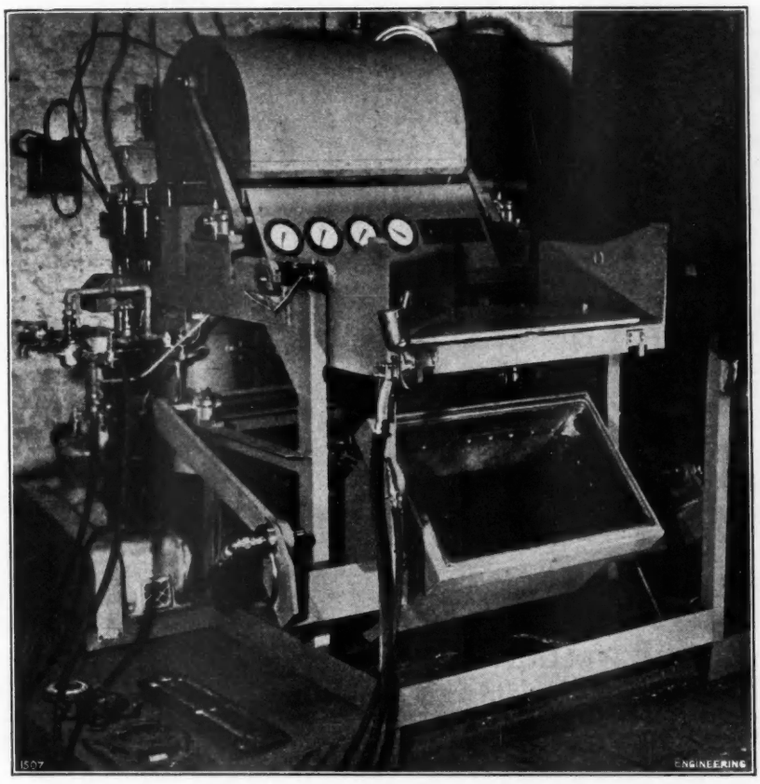


DETACHABLE END FITTINGS FOR HIGH-PRESSURE HOSE UNITS.—The Flexible Pipe Division of Bowden (Engineers), Ltd., Willesden Junction, London, N.W.10, have recently developed a range of high-pressure hose units with detachable end fittings capable of resisting the pressure and temperature conditions imposed by modern aircraft gas turbines. The units are available in a range of inside diameters from $\frac{5}{8}$ in. to $\frac{4}{32}$ in., capable of withstanding pressures up to 3,000-5,000 lb. per square inch. In the detachable coupling the hose-reinforcing wires are interlocked with the end fitting, which incorporates a lip seal. The fitting can be readily dismantled to facilitate inspection and replacement of worn parts.

SALTERS' SCHOLARSHIPS IN CHEMICAL ENGINEERING.—Applications are invited for a Salters' scholarship, the value of which is 350*l.* to 500*l* per annum, plus university fees according to circumstances, from graduates having an honours degree in chemistry, biochemistry, physics or engineering. The purpose of the scholarship is to furnish full-time instruction in the principles of chemical engineering or further experience by research in chemistry in order to qualify the candidate to enter the chemical industry. Applications may be made at any time during the year, and before graduation. Forms may be obtained from the Clerk of the Salters' Company, 36, Portland-place, W.1.

AUTOMATIC SHELL-MOULDING MACHINE.

CLINO FOUNDRY SUPPLIES, LTD., LONDON.



AUTOMATIC SHELL-MOULDING MACHINE.

RECENTLY we were given the opportunity to inspect a compressed-air operated shell-moulding machine which is fully automatic in action and is capable of producing half moulds or "biscuits," as they are often termed, in rapid succession once four timing devices have been set. The "Autoclino" shell-moulder, as it is named, has been designed by Mr. A. Wansbrough Jones, M.Inst.M.M., M.I.Chem.E., to the order of Clino Foundry Supplies, Limited, 25, Clyde Vale, Dartmouth-road, Forest Hill, London, S.E.23. It is illustrated above. For foundry use, the machine will be furnished with sheet-metal guards. The operation of the machine is simple. After a preliminary run to ascertain the length of the various time cycles involved, the four timing devices are set accordingly. These timing devices consist of four clocks arranged on a panel behind the machine. They can be hand-set to seconds for controlling the duration of the four operations of heating the pattern plate, investing the pattern, curing the shell mould and holding up the finished mould on ejector pins so that the operator can remove the shell. The mechanism of the machine is controlled by a master time switch, which gives a fixed duration for each motion. When it is required to vary the time cycle, the master time switch cuts out and the clock-actuated time switches come into operation.

The timing devices bring into action solenoid-operated pilot air valves, which in turn control the air at both ends of the air cylinders operating the machine. Air at 100 lb. per square inch pressure is supplied by a small electric motor-driven compressor and receiver. When the starting button, on the extreme right of the machine, is pressed, the heating hood, shown in its "at rest" position above the machine in the illustration, is swung over the pattern plate clamped horizontally in front of the machine. The hood, which is equipped with infra-red heating elements, preheats the pattern plate to a temperature of about 200 deg. C. After the set pre-determined time, the hood swings back and the pattern plate is reversed, ready to meet the dump box below it containing the sand-resin mixture. The dump box then rises to meet the pattern plate and both dump box and pattern plate are turned completely over to enable the sand-resin mixture to invest the pattern. After the set investment period, this movement is reversed to allow surplus mixture to fall back into the box, which is then lowered away from the plate. The pattern, with its adhering shell mould, now turns back to its original position and the heater hood swings over it for the final curing operation. After a set time, the hood returns to its "at rest" position. Finally, the dump box is lifted up to the ejector plate, which engages with a number of ejector pins; the latter are pushed upwards and raise the finished shell mould approximately 2 in. above the pattern plate, holding it for a predetermined time, during which the mould is lifted off by the operator. The dump box is then lowered again to its resting position of 45 deg. to the horizontal, as shown in the illustration. The machine is now ready to commence another cycle of operations, which occupies an average of from 2½ to 3 minutes.

The pattern plate of the machine measures 16 in. by 28 in., and in the case of the smaller castings can accommodate both halves of the mould. To prevent spilling of the sand-resin mixture when the box and pattern plate are inverted, a silicone gasket is fitted round the edges of the dump box. A pressure reducing valve is attached to the machine. This supplies air, at 20 lb. per square inch pressure, to a small gun used for spraying parting fluid on to the pattern plate at the commencement of operations. An air jet is also provided for blowing dust and foreign matter from off the pattern plate. Of the four dial gauges seen on the front of the machine, the two on the left indicate, respectively, the temperatures of the pattern plate and of an asbestos sheet under the hood when this is in the at rest position. The two right-hand gauges indicate, respectively, the pressure within the main air cylinder and that of the air supply to the spray gun and air jet.

SERVICEABILITY OF THE COMET AIRLINER.*

WITHIN 11 months of the inauguration of the world's first commercial jet service, Comet airliners of the British Overseas Airways Corporation were flying 122,000 miles a week on a network of routes with an unduplicated mileage of 20,780. Half of the B.O.A.C. routes were already employing Comets. In assessing the achievement it must be remembered that the Comet in use by B.O.A.C. during the inaugural year, the Series 1, was the undeveloped Comet and that the fleet of eight consisted of the first Comets off the production line. During 12,000 hours of service operation, many lessons, both operational and technical, have been learned. This valuable experience is being built into the succeeding generations of Comets, the Series 1A already in passenger service, and the Series 2 and 3, which are to follow.

Some degree of mechanical trouble is to be expected in a completely new type of aircraft and it is inevitable that in the early stages of service unfamiliarity and, perhaps, over-caution, will affect the serviceability standard. Mechanical delays were fairly prevalent at the start of the Comet service, and during the first month the average arrival time at the terminals was behind schedule to an amount equal to nearly 40 per cent. of the journey time. The standard of serviceability quickly improved and, finally, the time lost by mechanical delays was reduced to 9 per cent.

The majority of the troubles initially encountered were of a type which could quickly be eliminated as each aircraft became "bedded down" in service. For instance, hydraulic faults, which were fairly prevalent at first, have since become negligible at a figure of 2 per cent. of the total. In another category are faults which have required some degree of modification to prevent a recurrence, and which illustrate the truism that no amount of test flying can ever completely simulate the rigours of day-to day service operation.

One of the most serious faults, which nearly led to the temporary grounding of the fleet, was the misting of the windscreen, which without any previous warning suddenly started to occur in June, 1952, when the aircraft were on the final approach to Beirut and Khartoum airfields. This phenomenon occurred only in certain conditions of temperature and humidity. The cure, simple enough in principle but involving a fair amount of engineering, was to increase the flow of warm air across the inner face of the screen. This modification was incorporated in every aircraft within a very short period.

Of a similar but less serious nature was the trouble encountered with the early type of windscreen wiper which, having given every satisfaction during the test-flying period, proved to be unequal to the job on service. Its replacement by a more satisfactory type—hydraulically driven—was achieved only after a considerable amount of development work. Again, it was not until the aircraft encountered service conditions that some mal-distribution of the hot-air distribution in the de-icing system was discovered. The effect was not in any way serious because the Comet spends so little time at the ice-forming altitudes, but a modification of the ducts was put in hand forthwith. Finally, some evidence of cracking in the elevator skin was discovered, which has called for replacement of the skin in certain areas by a heavier gauge of metal.

In the Ghost engine, two main troubles may be mentioned. After some months of trouble-free running, cracks began to appear in the centrifugal compressors, the cause of which was finally traced to high-frequency vibration. These cracks in no case caused any noticeable effect on the running of the engine, and they were only discovered upon inspection. The cure was to crop the impeller blades by a small amount, not enough to affect the

* Extracts from an article received from the de Havilland Enterprise, Hatfield. The full text, entitled "The First Year of Jets in the History of Air Transport," is to be published in the June issue of the *De Havilland Gazette*.

efficiency, but sufficient to shift the frequency nodes outside the critical range. The other fault was a failure of a small ball-bearing supporting the shaft driving the generator cooling fan. This fan is required only during ground running, and its failure would not necessarily have rendered the engine unserviceable had it not been for the risk of the engine oil being contaminated by the damaged bearing.

It must be admitted that the necessity for incorporating modifications into the Comet fleet has had the effect of increasing the man-hours required for maintenance beyond the original estimate based on the initial proving trials with the pre-production aircraft G-ALZK. Even so, the yearly average of maintenance man-hours consumed for a major "check 4" routine inspection is still lower than for the best of the four-engined piston aircraft in the B.O.A.C. fleet. Now that the most important modifications have been incorporated and the maintenance is settling down to the normal routine, there is reason to suppose that the original estimate of about 2,500 man-hours for a "check 4" inspection will be achieved.

After the initial modification period was over, the record of the Ghost engine has been very good. During two of the monthly accounting periods there were no engine failures to record, but the average of 0·73 failures per thousand hours of flying—which compares favourably with B.O.A.C.'s piston engines—has been higher than might have been expected because of the short period of trouble mentioned previously.

Initially, the period between overhauls of the Ghost engine was limited to 250 hours, in accordance with the standard practice of the Air Registration Board for a new type of airliner engine. After a short operating experience, it was increased to 375 hours with a flame-tube inspection at 150 hours. In October, 1952, the period was again extended to 450 hours, and at the time of going to press approval is imminent for the Ghost to operate for 600 hours between overhauls, with flame-tube inspections at 200 hours. The introduction shortly of a modified flame-tube design is expected to raise the intermediate inspection time to at least 300 hours.

Apart from the vibration cracks in the impellers, already mentioned, two compressors out of the first 50 time-expired engines have been damaged beyond repair. On an average, three turbine blades have required replacement on each time-expired engine. In every case the damage to turbine blades was caused by objects passing through the engine, and there have been no cases of replacement due to thermal stress or fatigue. There has been no trouble with turbine discs and none has been replaced.

Since a failure would lead to extensive damage, the main bearings of the Ghost are subject to close inspection and are rejected if there is the slightest doubt as to their condition. The rejection of 12 front and 23 rear bearings on the first 50 time-expired engines can therefore be considered satisfactory. Of the 80 stator blades in each engine, an average of eight have been replaced in each time-expired engine. The introduction of hollow stator blades, with the consequent improvement in cooling, is expected to reduce this replacement rate considerably.

Some of the flame tubes have now achieved over 600 hours of running, and experience has shown that a large number of the defective flame tubes can be repaired by riveting and welding. Out of 50 time-expired engines a total of only six flame tubes have had to be scrapped. Approximately 15 per cent. of the flame tubes removed at intermediate inspections are replaced, but the majority of those damaged are repairable.

In summing up the record of serviceability for the first year of operation it can be stated that the Comet and its Ghost engines have earned unstinted praise from the engineering department of B.O.A.C. The incidence of faults with the first production aircraft and engines has been considerably below that which was expected. Starting at 200 hours, admittedly representing a cautious approach, the "check 4" period has been progressively extended to 1,040 hours. This rate of increase has not been approached by any other aircraft in the history of the Corporation.

ELECTRIC WELDING OF GLASS.

QUICKFIT AND QUARTZ, LTD., STONE, STAFFORDSHIRE.

ELECTRIC WELDING OF GLASS.

An open day was recently held at the factory of Quickfit and Quartz, Limited, Stone, Staffordshire, when members of the Press were invited to view the extensions to their works and see some of the latest developments in manufacture and fabrication of glass plant for industrial purposes. During the early part of this year, the company completed extensions to their premises amounting to about 25,000 sq. ft. These extensions include a new shop which is devoted to the production of the larger types of industrial glass plant. Most of the machinery used in this shop has been designed by the engineering staff of the company and the latest addition to their production equipment is a plant for the electric welding of glass. The illustration on this page shows a glass still the mouth of which is being heated by this new equipment prior to the joining of the two parts by welding.

This method of glass working, we understand, is the result of three years' development work and only brief technical details are available for publication. The process is based upon the fact that above a certain temperature, 350 deg. C. approximately, which is slightly below a dull-red heat, boro-silicate glass tends to lose its insulating properties and becomes a conductor of electricity. As the temperature increases an area of increased conductivity is produced through which the current can flow. With this process, it is still necessary to use a gas flame to heat the glass to the temperature at which it becomes a conductor. Two gas burners are employed for this purpose, one being visible in the illustration. The burners also serve as the positive and negative electrodes. The current flows from one electrode to the other through the heated band. The current used in this process has a high frequency of approximately 120 kilocycles per second and is produced by a quenched-spark oscillator which can be tuned to other frequencies when desired. The high frequency is used because it reduces the risk to the operator; the voltage is of the order of 10,000, and the heating results from the resistance of the conducting path. The current rapidly raises the temperature to a point at which the glass can be worked and blown in the usual way.

The advantages of this method of electric heating are its ability to heat the glass rapidly and locally without the wide spread of flame normally used, and to facilitate the manufacture of articles in a thick glass which was previously either extremely difficult or even impossible to work. With the previous methods of oxy-coal gas heating the flame played on the outside surface of the vessel and had to be conducted through the thick glass to inner surface before a joint could be made. With this electric heating method the heat is confined to a narrow band and does not depend upon the heat conductivity of the glass.

The mouth of the still and the neck shown in the illustration are each mounted in the specially designed chucks of a butt-sealing lathe which has two headstocks. One is stationary and the other can be moved longitudinally. Between the two headstocks is the carriage supporting the welding apparatus. The electrodes of this apparatus are located first on the neck of the vessel and then on the neck of the mouthpiece and moved from one to the other until the desired temperature is attained; meanwhile both parts are rotating at the same speed. At this temperature the current is cut off and the two parts are pressed together to produce the join. After slight cooling, the vessel is taken from the lathe and passed to the annealing kiln for the removal of the strains that may have been produced. The kilns are designed to ensure that no chilling draughts enter them and reintroduce stresses into the vessel when cooling. A polariscope is used for the final inspection of the finished vessel.

The company have also installed new research facilities with a view to still further improving their techniques. Most of their work is the production of laboratory glassware, which includes all-glass stills up to 18 in. in diameter.

Screw Thread Ready Reckoner.—W. H. A. Robertson & Company, Limited, Lynton Works, Bedford, have produced a ready reckoner known as "The Wharco Threadata Slide Gauge." It is designed to provide at a glance the major thread diameter, threads per inch, and the maximum and minimum diameters for medium fits, or class 2 fits in the case of unified threads. It covers the British Standard Whitworth system, British Standard Fine, British Association, metric, American national coarse, American national fine, and the unified coarse and fine which is now the standard thread for the United Kingdom, Canada and the United States of America. The smallest thread given is the 10 B.A., which has a major diameter of 1·7 mm., and 1½ in. is the largest major diameter among the remaining group of threads. The reckoner, which is in the form of a slide rule, is made of a white plastic material and has an inch scale provided along one edge and a millimetre scale along the other.

EXHIBITS AT THE BRITISH PLASTICS EXHIBITION.

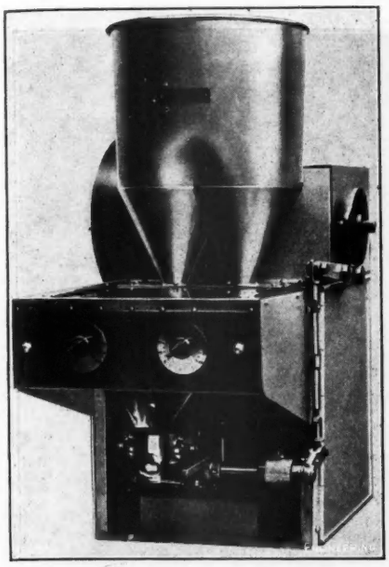


FIG. 1. "OSBORN" AUTOMATIC WEIGHING MACHINE; ALFRED HERBERT, LTD.

BRITISH PLASTICS EXHIBITION AT OLYMPIA.

As a result of the success of the first British Plastics Exhibition, in June, 1951, a second exhibition is now being held at Olympia from June 8 to 18. It was officially opened on Monday by Mr. C. E. Wallis, managing director of the Associated Iliffe Press, and Mr. C. S. Dingley, chairman of the British Plastics Federation, and it is being sponsored and organised by the journal *British Plastics*, with the support of the British Plastics Federation. Running concurrently with the exhibition is a Convention, which is being held in the Convention Hall on the first floor. It consists of 23 papers covering developments and practices in the industry. Lord Halsbury, managing director of the National Research Development Corporation, opening the Convention, gave an inaugural address on "Reinforced Plastics—Public Invention and the Introduction of Royal Aircraft Establishment Techniques to Industry." We give below brief descriptions of some exhibits of engineering interest.

"OSBORN" AUTOMATIC WEIGHING MACHINE.

Among the exhibits being shown by Alfred Herbert, Limited, Coventry, is the Osborn automatic weighing machine, which is illustrated in Fig. 1, herewith; the three other principal exhibits on this company's stand are the 100-ton low-pressure press for glass-fabric moulding, made by T. H. and J. Daniels, Limited, Stroud, Gloucestershire, the Edgwick automatic injection moulding machine and a 100-ton enclosed-type press.

The Osborn weighing machine has been designed to facilitate and to increase the speed of processes where a continuous flow of materials is required in accurately weighed amounts. Four standard sizes of the machine are being made, for weighing single batches of up to ½ lb., 1 lb., 4 lb., or 16 lb.; special-purpose machines can be built to order that will weigh up to 112 lb. The machine can also be used to give a controlled delivery of components at any desired rate up to sixteen items per minute. Examples of the products which can be handled include chemical, metallic and plastic powders, as well as pellets, rivets, nuts and bolts, split pins, nails, screws and springs. From the combined hopper, the machine has two gravity feeds in parallel, one a fine feed used to complete the batch after the other, a bulk feed, has been cut off. The material is fed from the hopper through the bulk-feed and fine-feed conical openings to independent vibrating trays and, from these trays, it is fed at

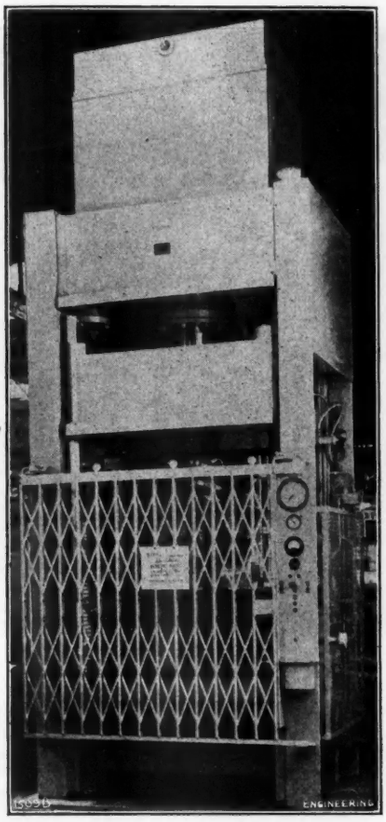


FIG. 2. AUTO-CONTROL LOW-PRESSURE PRESS; B.I.P. ENGINEERING, LTD.

pre-set rates through two feed nozzles to be discharged on to the weigh pan. The material continues to flow at the pre-selected rate until the quantity in the pan is just short of the full weight; the bulk feed is then stopped and the batch completed by the fine feed alone. With a full batch in the pan, both feeds are closed, the weighed material is discharged on to the conveyor-belt system and the cycle recommenced. The quantity handled in each batch is controlled by a simple lever-arm mechanism operated by a dead weight placed on the weight cradle. The rate of delivery of the material to each batch is adjusted by altering the speed of the vibrating trays.

AUTO-CONTROL LOW-PRESSURE PRESS.

B.I.P. Engineering, Limited, Aldridge-road, Streetley, Staffordshire, are displaying five machines, four of which are said to be new designs. Fig. 2 shows their Bipel auto-control low-pressure press. It has been designed to meet the requirements of plastics such as polyesterepoxy resin plastics, reinforced with glass, asbestos, or other fibres. It has a long stroke that can be adjusted to suit the particular task, and a platen which is approximately 4 ft. square. The pressure on the platen can be varied over the total range between 3 tons and 150 tons. There are three closing speeds, and across the front of the machine is a safety guard in the form of a gate; this guard is coupled with the starting control so that the closing of the gate automatically brings the press into operation. A mould parting force in excess of 30 tons can be applied. The bottom table of the press is arranged so that hydraulic pressure causes it to slide out for ease of access when loading or to increase the effective length of stroke.

50-TON PLASTIC MOULDING PRESS.

One of the most interesting exhibits at the Exhibition is the new "Lancastrian" 50-ton plastic-moulding press, which is fully automatic in

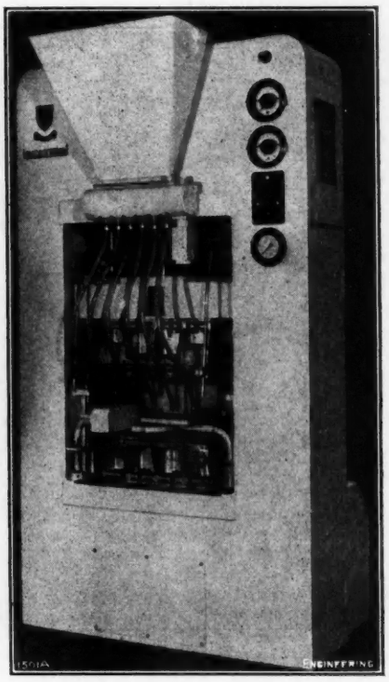


FIG. 3. 50-TON PLASTIC-MOULDING PRESS; FOSTER, YATES & THOM, LTD.

operation and is manufactured by Foster, Yates and Thom, Limited, Blackburn. This machine, illustrated in Fig. 3, above, is completely automatic in every sense, from the powder measurement and feed to the final ejection and checking by weight of the finished mouldings. The total time cycle is 15 seconds plus the curing time, which, naturally, varies with the type of moulding being produced and the composition of the powder used. The press is not large and occupies a floor space only 4 ft. 3 in. by 2 ft. 6 in.

The powder-feed mechanism is simple; powder is first placed in the hopper, from which it passes through the control slots, or gates, which may be seen in line immediately below the hopper, and serve merely to cut off the supply. It then falls by gravity into six cavities cut in a line, parallel to the axis, in a horizontal cast-iron roller; each of these cavities has a false bottom which is screwed in or out with an ordinary screw-driver, in order to adjust the capacity of each cavity to the work required. The roller then rotates through 120 deg., cutting off the supply of powder and emptying the contents of the cavities into the six feed tubes; the roller is then returned for refilling the cavities, the movement being by rack and pinion. The feed tubes may be arranged to feed six moulding cavities, or one cavity of 36 cub. in. or any combination between these limits.

Pressure is supplied at 2 tons per square inch by a Towler "Electraulic" pump working on the swash-plate principle, and the sequence of operations is controlled by a patented cam controller which directly operates contactors energising either timers or valve solenoids. In the sequence of operations the cam controller first energises the powder feed for five seconds and then energises a solenoid to bring down the main ram; a timer then stops the cam mechanism, and re-starts it when the ram is brought up for the breathing lift. A breathing timer then takes over, followed by closing of the press for a period determined by the curing timer. At the end of the curing period the press opens and ejects, the feed is re-set and the machine stops, re-starting only if the pre-set scale pan falls and re-makes the electrical circuit. Should the scale pan not fall, an alarm rings.

(*To be continued.*)

THE CONTINUOUS PRODUCTION OF TIMBER BOARD.

VERE ENGINEERING CO., LTD., MARKS TEY, ESSEX.

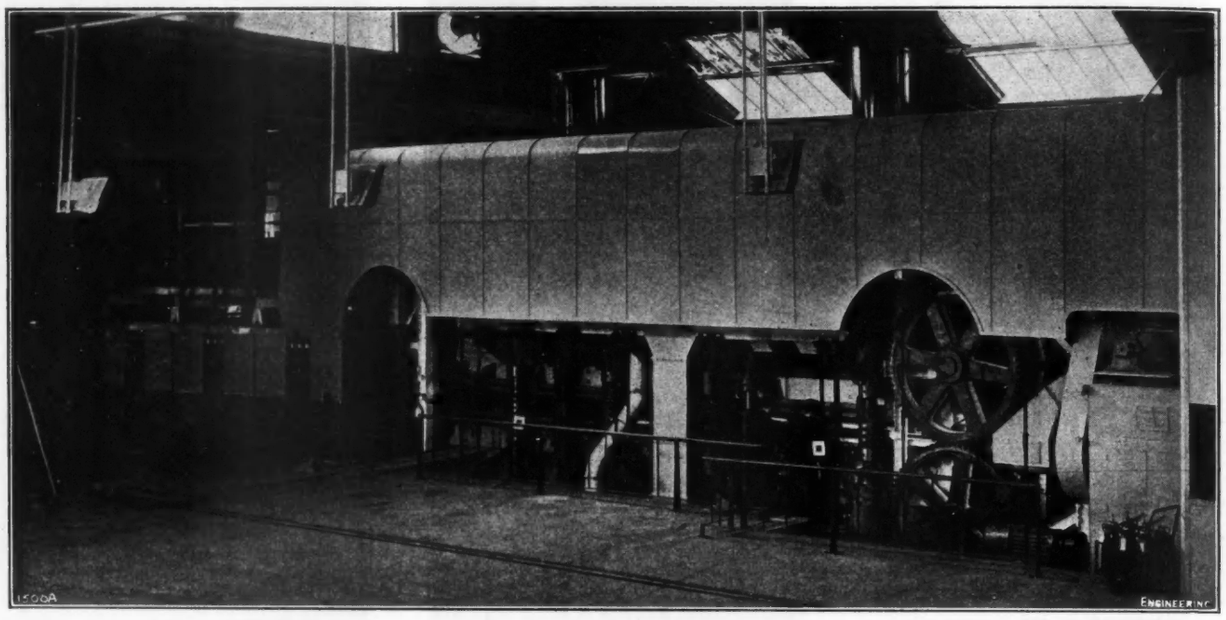


FIG. 1. GENERAL VIEW OF PRESS.

THE CONTINUOUS PRODUCTION OF TIMBER BOARD.

THE mass production of timber board has become a commercial fact by the installation, in a factory at Marks Tey, near Colchester, Essex, of a press for the continuous conversion of wood chips into a resin-bonded fibre board. Wall boards of various types, and from various materials, have been made since the beginning of the century, but the world shortage of timber and plywood during and after the last war has encouraged a further examination of the means to reduce wastage, at present amounting to 60 per cent. of the total timber handled by the world's lumber industries. This examination has been accelerated by mechanisation in the building industry, by the wider acceptance of factory-made units and by the stricter application of quality standards at a time when both the quality and quantity of natural timbers are declining. The solution of the problem involved the reconstitution of otherwise unusable timber, and the production of wall-board and fibre-board increased at the rate of 100 per cent. in every three-year period since the war; this, however, was still insufficient to meet demand.

Prior to the installation of the new press, the existing processes were all based, in their latter stages, on a platen press, involving single-sheet batch loading and a pressing operation of long duration combined with slow curing—which produced an end-product of three fixed dimensions. The advantages to be gained by the introduction of continuous processing were recognised before the war, and in 1939 the British Artificial Resin Company was formed and research was instituted on the development of such a process for converting bonded wood flakes and chips into building board. In spite of the war, the first designs for a continuous press were completed during 1943. Four years later, the first pilot plant was in operation, making boards 18 in. wide.

The first full-size commercial plant is that at Marks Tey, belonging to the Vere Engineering Company, Limited, 3, Vere-street, London, W.1. Output, which will reach normal in a few months time, will be at the annual rate of 16,000 tons, or between 25 and 40 million sq. ft., according to the thickness of the board produced. The standard board is 4 ft. wide and it can be rolled to any thickness between $\frac{1}{16}$ in. and $\frac{1}{2}$ in.

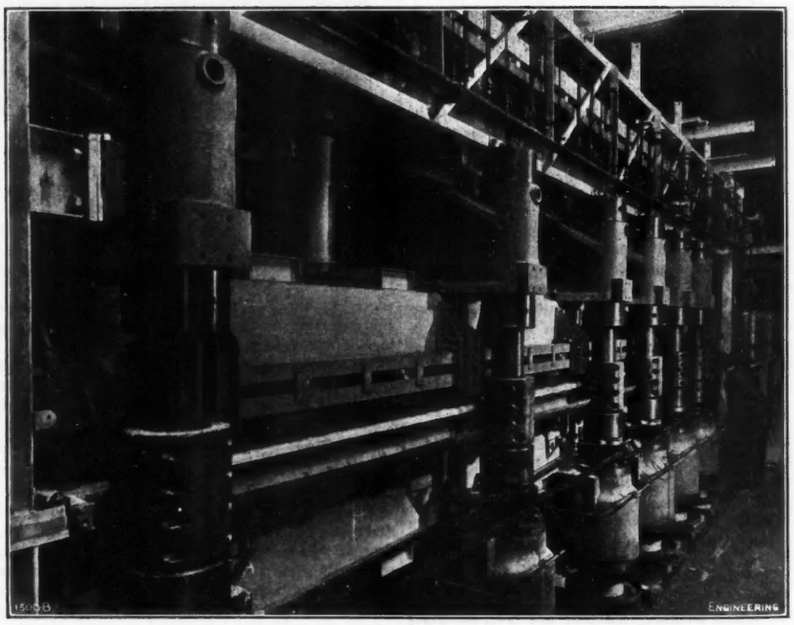


FIG. 2. PRESSURE ZONE OF PRESS.

THE PROCESS.

The process, which is to be known as the Bartrev process, is designed to produce a high-quality board from fibrous materials, of which the most easily available is timber that would otherwise go to waste. Such timber waste inlcudes cuttings, tops and branches that the lumber industry cannot use, together with wood waste from sawmills and other factories. Hard woods are as suitable as soft woods and the choice of raw material will depend only upon supply, though the character of the end product will, of course, vary somewhat with variation in the waste that is used.

Two preliminary stages are common to all board-making processes: that of reducing the raw material to a uniform and correct particle size and that of controlling the humidity. For the first of these stages, either shaving or hammering is suitable, and a pneumatic drier has been found most convenient for controlling the moisture. For the plant at Marks Tey, which has access to an adequate supply of soft-wood shavings, the raw-material preparation plant includes the following units: batch grinders that will reduce the shavings by hammering to the correct particle size; a pneumatic system which carries the particles to a vibratory screen used for separating the undersized particles; a pneumatic drier to control the moisture (the material is over-dried and then pre-heated by the introduction of

CONTINUOUS PRODUCTION OF TIMBER BOARD.

VERE ENGINEERING CO., LTD., MARKS TEY, ESSEX.

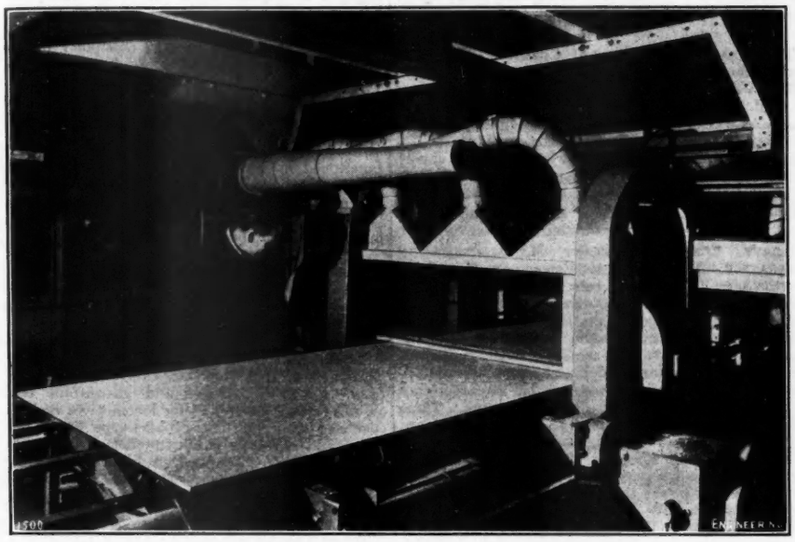


FIG. 3. FINISHED BOARD LEAVING PRESS.

steam which will bring the moisture content back to the optimum); a raw-material storage bin, fitted with a controlled discharger; and the resin-mixing units. Because of the short curing cycle of the Bartrev process, say, 30 minutes, quick-setting resins have to be employed. According to the type of wood used and the properties required in the end product, the proportion of resin to raw material varies from between 5 to 8 per cent.

The continuous press, which is illustrated in Figs. 1 to Fig. 3, and in Figs. 4 to 7 on page 752, is an assembly of four essential parts, namely, a feeding unit, a high-frequency heating unit, the press itself, and an automatic saw. The whole unit, shown in Fig. 1, has the following overall dimensions: length 134 ft.; width, 7 ft. 6 in.; height 20 ft.; weight, about 200 tons. The feeding unit receives the resin-mixed raw material in an automatically loaded hopper equipped with a selenium-cell control which cuts off the supply when the hopper is full. From the reception hopper, the raw material passes down a gravity chute to be spread uniformly on the lower of the two endless belts of stainless steel that carry the material through the press.

Temperature has a marked effect on the compressibility of the raw material and research has shown the desirability of pre-heating the resin-wood mixture before commencing the main step in the process. For this purpose of pre-heating, three high-frequency heating units have been installed, one of which is shown in Fig. 4. During its passage past the heaters, the temperature of the material is raised to between 85 deg. and 90 deg. C.; this temperature is not sufficient to cause either excessive evaporation of moisture or to bring about pre-curing of the resin.

The press itself is illustrated in Fig. 2, opposite, and in detail in Figs. 5, 6 and 7, on page 752. The raw material is actually carried on the lower of two steel facing belts and is formed, under pressure, between the lower and upper belts shown, in Fig. 5, passing over the return drums; the mounting of these drums is such that adjustments can readily be made to ensure a true parallel movement and enable the necessary tension to be maintained. The pressure required during the process, 500 lb. per square inch, is obtained from two endless platen chains which are heated to promote the curing process; the heavy roller-bearing races used to carry the platens are shown in Fig. 6. Particular attention was paid in the design stages to the details of these platen chains with the object of minimising the damage that can be done by the platens to the facing belts, and to achieve the required distribution of pressure as the raw material enters the press. The resin-wood mixture entering the press is shown in Fig. 7. The compacting process consists of two stages, the first being the expulsion of the air from the voids and the rearrangement of the particles to fill the voids, the second being the actual compression of the particles themselves. During the second stage, the maximum pressure that can be developed is required, but after that stage has been completed and curing of the resin has commenced only sufficient pressure is required to hold the board at its correct thickness by preventing recovery. The final heating stage is effected in the press by the transfer of heat from the lower platen chain which is itself raised in temperature by radiant heat during its return journey below the press. The temperature of the raw material is, by this heat, raised to between 110 deg. and 115 deg. C., according to the type of board being made. This temperature is maintained by thermostatic control until the finished board leaves the pressure zone, fully cured and fully compressed. Modification to the thickness of the board being produced involves closing the gap between the endless-belt systems; this is effected by raising the bottom unit of the press *en bloc* by jacks shown in Fig. 2.

At the delivery end of the press, an automatic saw unit has been installed to make two operations: firstly, to trim the edge of the board as it emerges from the press; secondly, a high-speed circular saw mounted on an overhead beam, travelling at the same rate as the board, cuts off the board in pieces of any required length. The entire press and the ancillary equipment is driven by a single electric motor, operating through a gearbox that gives board speeds between 5 and 30 ft. per minute. This permissible variation in speed gives the process considerable versatility, enabling marked variations in the raw materials and resin contents, thickness and density of the board to be readily accommodated. Although the board is stable as it is rolled, equipment has been fitted to allow a paper surface to be rolled on to one or both sides of the board during processing. The paper is coated with resin and is fed on to the steel bands prior to the wood-resin carpet being fed into the press.

PROPERTIES OF "BARTREV" BOARD.

The board, which is to be marketed under the trade name of Bartrev is thus made by a process from which the human element has been almost entirely eliminated and the resultant end-product of any given grade exhibits uniform properties to a high degree. The uniform texture of the board ensures that any tendency to warp is largely excluded.

Three grades of board are being produced: the plain board from shavings, the same board but paper-covered, and a better-quality board from specially-prepared wood chips. In each of the three grades the density can be varied from about 32 to 45 lb. per cubic foot, according to the nature of the raw material and the degree of pressure applied during the formation of the board. The compressive strength of the board varies only slightly between the different grades and for different densities, from 2,500 lb. to 2,800 lb. per square inch, but both the tensile strength and the modulus of rupture increase both with density and with the grade, the tensile strength increasing from 1,900 lb. to 3,100 lb. per square inch, and the modulus doubling from 2,500 lb. to 5,000 lb. per square inch. Irrespective of grade or density, the effective modulus of elasticity (secant modulus to a standard proof stress) is 135 tons per square inch; similarly, the thermal insulation is almost constant at 1·0 B.Th.U. per hour per square foot per deg. F. per 1 in. thickness of board. The resin being nearly inert, the board has a reasonable degree of non-inflammability, falling within category II of B.S. No. 476, which requires charring or scorching not to extend for more than 2 in. from the edge of the underside of a 6-in. wide sheet. As manufactured, the resin at present used in the board is both vermin-free and sterile, but over and above this, it would be a simple matter to meet particular overseas demands and to embody fungicides to mitigate the effects of attack by either vermin or fungi.

The board is workable by all normal joinery methods, using either hand or machine tools. It can be cut, sawn, screwed, nailed and glued like wood. As with plywood, it is advisable not to nail too close to the edge, screw-fixing is facilitated by pre-drilling, and ordinary Scotch glue, casein or any synthetic-resin glue is suitable for bonding joints. The unfaced board has a sufficiently smooth surface not to require filling before painting, other than the paint-maker's recommended undercoat. The natural characteristic appearance of wood can be obtained by either waxing or applying a coat of transparent varnish or cellulose. As a core material, Bartrev board makes a good backing for any of the popular wood veneers, applied with either hot- or cold-setting glues, or for the high-pressure plastic laminates.

The applications for which the board can be used are as wide as the use of wood itself, with the exception of the heavy structural uses of timber. For the building industry it forms an alternative lining material for walls, ceilings and floors, appropriate finishes being selected for the decorative effect that is required. For furniture, the board makes an excellent core between veneers for all forms of cabinet or case-built fitted units; as a backing behind plastic laminates, the board can be used for heavily used table tops, counters and kitchen units. As a lining, the board can be used with a variety of finishes for many types of road and rail vehicle, and, in this respect, its fire-resistant properties recommend it.

CONFERENCE ON FIRING OF SOLID FUELS IN SMOKELESS ZONES.—With the object of assisting users of solid-fuel appliances in the Manchester smokeless zone, and in similar areas elsewhere, the Combustion Engineering Association has arranged to hold a whole-day conference on "The Firing of Solid Fuels in Smokeless Zones" at the Engineers' Club, Albert-square, Manchester 2, on Tuesday, June 23. At the morning session, commencing at 10.30 a.m., there will be papers on "The Available Fuel," by Mr. R. A. Howson, and on "Smokeless Firing in Domestic Premises," by Mr. W. C. Moss. Two papers will be read at the afternoon session, commencing at 2.15 p.m., namely, "Smokeless Firing in Commercial Premises," by Mr. E. Murphy and Mr. E. L. Tinley; and "Smokeless Firing in Industrial Premises," by Mr. S. N. Duguid. Discussions will follow each paper, and the proceedings of the conference will be summarised by Dr. A. C. Dunningham. Further information may be obtained from the secretary of the Association, 6, Duke-street, St. James's, London, S.W.1.

NOTES FROM THE INDUSTRIAL CENTRES.

SCOTLAND.

WHITEINCH-LINTHOUSE TRAFFIC TUNNEL.—Following the submission, on June 1, to the Highways Committee of the Glasgow Corporation, of reports showing that test borings have given satisfactory results and have confirmed the line of the Whiteinch-Linthouse traffic tunnel under the Clyde, as planned by the City Engineer's Department, strong representations are to be made to the Secretary of State for Scotland and the Minister of Transport for authority to proceed with the project. The tunnel has been estimated to cost 3,000,000*l*.

CANCELLATION OF ORDER FOR A MOTOR TANKER.—United Whalers, Ltd., have cancelled a contract for the construction of a motor oil tanker of 20,000 tons deadweight capacity placed on the Clyde. The hull of the vessel was to have been built by Lithgows Ltd., Port Glasgow, and the propelling machinery by David Rowan & Co., Ltd., Glasgow.

EXTENSIONS TO A STRUCTURAL STEEL WORKS.—In order to step up production, A. G. McFadden & Co., structural-steel manufacturers, Rutherglen, were granted permission, at the Rutherglen Dean of Guild Court, on May 27, to carry out extensions to their Farmeloan-road works estimated to cost 30,000*l*. The extensions will be carried out in three stages.

FIRE AT A ROPE WORKS.—Extensive damage was caused, on May 27, by a fire at the premises of Greenock Ropeworks, Ltd. The fire started in a breaker card machine when a spark ignited a quantity of tow. The flames spread through extractor pipes to a filter unit in the rope store. Rollers in the breaker card machine and other plant were damaged.

TELEVISION RECEPTION ON ISLE OF MULL.—Television tests just carried out on the Isle of Mull, which had been considered well beyond the zone for satisfactory reception, have proved so successful that the first sets were installed in the island last week. Experts expressed surprise at the excellent results.

GLASGOW PRODUCTIVITY COMMITTEE.—We regret that the name of the chairman of the newly-formed Glasgow Productivity Committee was wrongly given on page 686, *ante*. He is Mr. John Malley, a director of the Mirrlees Watson Co. Ltd., Scotland-street, Glasgow, C.5.

CLEVELAND AND THE NORTHERN COUNTIES.

NEW FORE-END FOR "DUKE OF YORK."—Palmers (Hebburn) Co., Ltd., have received the contract for the construction of a new fore-end for the mailboat Duke of York, which was cut in two in a collision with an American ship off Harwich. The work, which will be carried out at Palmers' Jarrow-on-Tyne dock, is expected to take four or five months.

ALUMINIUM BRIDGE FOR ABERDEEN.—Messrs. Head, Wrightson Aluminium Ltd., Thornaby-on-Tees, have completed the construction of an aluminium bridge to span the 70-ft. entrance to the Victoria Dock, Aberdeen. This, it is stated, will be the first aluminium-alloy bridge in Scotland. Some time ago, Messrs. Head, Wrightson built a similar bridge for the port of Sunderland.

LONGBENTON FACTORY.—Vickers-Armstrongs Ltd. are postponing a start on the construction of their new factory at Longbenton, near Newcastle-on-Tyne, and the position will be reviewed again at the end of the year. It is understood that orders are not as plentiful as they were some months ago and this, and other reasons, are responsible for the postponement of the plan. The proposed Longbenton works are expected to cover 100 acres and will manufacture light tractors.

TYNE SHIPBUILDING ACTIVITIES.—Two launches on the Tyne this month will bring the river's output for the first half of the year to 12 vessels aggregating about 107,500 gross tons, compared with seven vessels totalling 57,950 tons in 1952. The launches for June include the Saxonmead, of 13,300 tons, at Vickers-Armstrongs Ltd., Walker Yard, for Stavros S. Niarchos, and the Anglo-Saxon Petroleum Co.'s tanker Haustrum, of 12,250 tons, built by Hawthorn, Leslie & Co., Ltd., Hebburn.

ENLARGEMENT OF SHIPBUILDING DOCKS AT BLYTH.—Blyth Dry Docks and Shipbuilding Co., Ltd., are in touch with the Blyth Corporation for the acquisition of land for further extensions to their shipyard. The proposed extensions will allow shipbuilding berths to be laid out at an oblique angle to the river, thus allowing for the launching of larger ships in a down-river direction. The Blyth yard already has several ships of 18,000 tons on order and it is understood that ships of 20,000 tons deadweight capacity can be built.

TEES TRADE STATISTICS.—At a meeting of the Tees Conservancy Commission at Middlesbrough, it was reported that the tonnage of vessels clearing the river in April, at 409,977 net tons, was the highest on record. The total was more than 53,000 tons higher than that for April last year. Imports during April, at 357,026 tons, were 39,711 tons more than last year, due chiefly to higher imports of coal, scrap and iron ore. Exports at 126,224 tons were about 40,000 tons less than those for March.

HEAVY ELECTRICAL PLANT MANUFACTURE IN NEWCASTLE.—Messrs. C. A. Parsons & Co., Ltd., Newcastle-on-Tyne, have been complimented upon their speedy delivery of turbo-alternators for the Richard L. Hearn power station, Toronto, Canada. Following a fire at a hydraulic power station, it was necessary to concentrate on the Toronto steam station. As a result of the prompt delivery of Parsons' equipment to this station, it was possible to accept an increased load without resorting to power cuts. Three 100-MW turbo-alternators for the Richard L. Hearn power station have been commissioned and the fourth is ready for use. Recently the British Electricity Authority ordered a second 100-MW turbo-alternator for Ferrybridge power station while additional orders for transformers have been secured by the firm for power stations at Stella North and South, Ferrybridge, Connah's Quay and East Yelland. Two 15-MVA transformers have been ordered by the North-Eastern Electricity Board and one of 10 MVA by the Midlands Electricity Board.

LANCASHIRE AND SOUTH YORKSHIRE.

REFRIGERATOR WAGONS FOR AFRICA.—A special transhipment bogie has had to be designed and made for the transport of refrigerator wagons of unusually large dimensions ordered by the Rhodesian Railways from Cravens Railway Carriage and Wagon Co., Ltd., Sheffield. The first batch of 34 wagons, each 42 ft. long and 11½ ft. high, has been dispatched and it is hoped to complete the contract within six or eight months. The wagons are required for maintaining perishable goods fresh on long trans-African journeys.

IMPROVED INDUSTRIAL OUTLOOK.—Improved sales of motor cars are having an effect in iron and steel works making motor-car components. Many employees in Sheffield and Rotherham steelworks and in several iron foundries of the district, who were put on short time when orders for components fell off sharply some little time ago, are being put on full time again, and the prospects are said to be much brighter.

COAL OUTPUT FALLS.—There has been a sharp fall in coal production in Yorkshire, as a result of the Whitsuntide holidays, as well as the annual holidays at six collieries. Production in the week ended May 30 was down to 637,000 tons. South Yorkshire collieries produced 236,000 tons less than the week before. The consumption of locomotive hards considerably increased as a result of heavier holiday train traffic and the running of Coronation specials. The 1953 annual pit holidays will impose a greater strain upon production, as, this year, the holiday break is for a fortnight instead of for a week.

THE MIDLANDS.

BIRMINGHAM COLLEGE OF TECHNOLOGY.—Birmingham College of Technology has been offered a research scholarship by International Combustion Ltd., Derby. It is worth 500*l*. a year, and is for research into the presence and elimination of sulphur dioxide in combustion gases. The lecturer in chemistry at the College, Dr. G. H. Tolley, obtained his doctorate as a result of his work on the sulphur-trioxide problem, and if the governing body of the College accepts the scholarship, as it is expected to do, the work will be directed by Dr. Tolley.

BIRMINGHAM TRAMWAYS.—The last tramway cars in Birmingham are scheduled to cease operation on July 4. The track at present in use starts near the City centre and proceeds in a north-easterly direction for about 2½ miles, and like all those formerly existing in Birmingham, is of 3 ft. 6 in. gauge. The last car will run at about mid-day on July 4, and the service will then be operated by Diesel-engined omnibuses.

CO-OPERATION FOR EXPORT.—Thirty companies engaged in engineering in the Wolverhampton area have responded to an invitation from the Wolverhampton district committee of the National Union of Manufacturers to consider the possibility of working as a group to enter the export trade. Representatives of the firms concerned are to meet in the near future to discuss plans. Mr. F. E. Woodward, chairman of the Wolverhampton district branch of the National Union of Manufacturers, has given an example of a successful co-operative scheme which has already functioned in Birmingham. An enquiry, he stated, was received from the dollar area for an adjustable spanner of a type not made by any of the local manufacturers, but three N.U.M. members took an order jointly, and completed it satisfactorily.

EXHIBITION OF FILTERS AND SILENCERS.—A special-feature exhibition of apparatus manufactured by Vokes, Ltd., Henley Park, Guildford, was opened to-day at the Imperial Hotel, Temple-street, Birmingham, and will continue until Saturday, June 20. A representative selection of the firm's products will be on view, including air, lubricating-oil and fuel filters for petrol, Diesel and gas-turbine engines; air-filter panel assemblies for locomotives and railway coaches; air-conditioning panel-type filters for factories and offices; and high-efficiency canister-type air filters for the collection of sub-micron size dust and bacteriological particles. The exhibition, which is the third of its kind, is open to the public.

TRACK LAYING FOR THE TALYLLYN RAILWAY.—The Talyllyn Railway Preservation Society, which is largely composed of Midland light-railway enthusiasts, have accepted an offer made by the Chief Engineer, Western Command, of the services of a Territorial Army unit of the Royal Engineers to re-lay about two miles of the railway track. The army unit will do the work free of charge as part of its summer training programme. The necessary materials, however, will have to be provided by the railway, and the Society are endeavouring to raise 1,500*l*. for this purpose.

SOUTH-WEST ENGLAND AND SOUTH WALES.

SOUTH WALES EXPORTS.—In spite of a collapse of exports to France which has been South Wales's biggest customer, steady progress has been maintained in the foreign coal trade. Official returns issued by the Docks and Inland Waterways Executive show that up till mid-May, South Wales sent 1,436,816 tons of coal and coke to foreign destinations compared with 1,272,025 tons in the corresponding period of last year. On the other hand, exports of patent fuel fell sharply from 157,016 tons in 1952 to 60,147 tons this year. The tin-plate export trade has been steadily maintained at 101,541 tons, compared with 99,449 tons a year ago, while iron and steel manufactures rose from 88,579 to 95,319 tons. The activity in the local iron and steel industry has been reflected in the jump in arrivals of iron ore from abroad, from 692,622 to 908,177 tons, while partly-manufactured iron and steel goods and scrap have risen from 214,846 to 287,954 tons.

TRAFFIC AT S. WALES PORTS.—Latest statistics issued by the Docks and Inland Waterways Executive, South Wales ports, show a decrease so far this year in the total trade of the ports in this area. From January 1 to May 17 last, 8,303,464 tons of traffic were handled against 8,491,009 tons in the corresponding period of 1952. Imports were up from 3,555,486 tons to 3,741,814 tons, but exports fell from 4,935,522 tons to 4,561,650 tons.

ANTHRACITE COLLIERY SINKING IN CARMARTHENSHIRE.—The necessary arrangements for the sinking of a new anthracite pit, estimated to cost 7,500,000*l*., are well in hand, Mr. G. S. Morgan, production director of the South Western Divisional Coal Board, has assured the Carmarthenshire County Development Committee. The new colliery will be at Cynheidre, in the Gwendraeth Valley. Since the Board's announcement of its plan for the new colliery three years ago there has been a great deal of concern at delays in starting the project. Repeated approaches have been made to the Board and it is understood that the delays have been caused by necessary amendments to the plans as borings have disclosed variations in the direction of the coal seams. Six seams of best anthracite will be worked, and workable reserves are placed at more than 100,000,000 tons.

BRITISH STANDARD SPECIFICATIONS.

THE following publications of engineering interest have been issued by the British Standards Institution. Copies are available from the Sales Department of the Institution, 24, Victoria-street, London, S.W.1, at the prices quoted at the end of each paragraph.

Primary Cells and Batteries for Coal Mines.—A new specification, B.S. No. 1975, covers primary cells and batteries for intrinsically safe bell signalling circuits in coal mines. It deals with Leclanché-type primary cells and batteries, which in order to be safe, are to be constructed in such a manner that the current is limited to a specified amount in order that the sparks produced in the signalling circuits are incapable of igniting inflammable gas. Details of the dimensions of the component parts, the composition of the electrolyte for the wet cells and requirements for the performance of the complete cells are specified. [Price 2*s.* 6*d.*, postage included.)

Corrugated Furnaces for Cylindrical Boilers.—Another new specification, B.S. No. 1971, deals with corrugated furnaces for cylindrical boilers, and supersedes B.S. No. 3023 : 1926 which dealt with corrugated furnaces and smoke tubes for marine boilers. The new publication specifies requirements for corrugated furnaces for both land and marine cylindrical boilers and covers the FOX, Morison, Deighton and suspension-bulb types of furnaces with various throat designs and typical connections for riveting and welding. Dimensions of corrugations and lengths of furnace are given, together with formulae for determining the minimum thickness of the furnaces. Requirements for materials, construction and heat treatment, are also furnished. The shapes of furnaces and end connections are illustrated. [Price 5*s.*, postage included.]

Large Aluminium-Alloy Rivets.—A third new specification, B.S. No. 1974, is concerned with large aluminium-alloy rivets intended for use in the general engineering and shipbuilding industries. It has been confined, for the present, to the range of rivet types and sizes now coming into current use. The publication provides for small snap-head rivets, conical-head rivets, small pan-head rivets, rounded or flat countersunk-head rivets, and shallow rounded or flat countersunk head rivets. Materials and dimensions and the head shapes of the rivets of nominal sizes ranging from ½ in. to 1 in. diameters are specified. It is pointed out that large aluminium-alloy rivets are a recent development and that experience in their manufacture and use is rapidly increasing. In view of this the methods of testing finished rivets are being studied further and arrangements are being made to review the specification in about two years' time. [Price 4*s.*, postage included.]

CONTRACTS.

THE FAIREY AVIATION CO. LTD., Hayes, Middlesex, inform us that the AIR SURVEY CO. LTD., have received an order placed on behalf of the Director of Colonial Surveys by the Crown Agents for the Colonies for the survey, by air, of some 30,000 sq. miles in Uganda, Tanganyika and Kenya.

THE GENERAL ELECTRIC CO. LTD., Magnet House, Kingsway, London, W.C.2, have obtained a contract worth 1,400,000 dols. from the United States Air Force in Europe (Procurement Division) for ground-to-air very-high frequency radio transmitters, receivers and spares of a design similar to equipment now being manufactured by the company for the Ministry of Supply. The transmitters will be supplied to N.A.T.O. countries.

R. A. LISTER & CO. LTD., Dursley, Gloucestershire, have received an order valued at 750,000 dols. from the United States Army authorities in Europe for generating plant for use with radar sets.

THE INTERNATIONAL NICKEL CO. OF CANADA, LTD., have announced that they have signed a contract under which the United States Government have purchased, for speedy delivery, a total of 120,000,000 lb. of metallic nickel and 100,000,000 lb. of electrolytic copper. The contract has been concluded with the Defence Materials Procurement Agency. Deliveries under the contract are to commence in December and will be at a rate of 2,000,000 lb. per month for nickel and 1,666,666 lb. per month for copper.

BRUSH BAGNALL TRACTION LTD., a member firm of the Brush Group of Companies, have received an order from the South Wales Division of the National Coal Board for two 400-h.p. 0-6-0 Diesel electric shunting locomotive for use at the Cwm colliery. The locomotives are to be equipped with NATIONAL R4AA6 engines and BRUSH electrical equipment, comprising main and auxiliary generators, traction motors and control gear. The mechanical parts of the locomotives will be manufactured by W. G. BAGNALL, LTD.

NOTICES OF MEETINGS.

IT is requested that particulars for insertion in this column shall reach the Editor not later than Monday morning in the week preceding the date of the meeting.

INCORPORATED PLANT ENGINEERS.—*Merseyside and North Wales Branch :* Monday, June 15, 7.15 p.m., Radiant House, Bold-street, Liverpool. "Industrial Smoke Abatement," by Mr. P. H. Saunders. *Hertfordshire Discussion Group :* Tuesday, June 16, 7.30 p.m., Peahen Hotel, St. Albans. Discussion on "Dust Extraction."

ROYAL METEOROLOGICAL SOCIETY.—Wednesday, June 17, 5 p.m., 49, Cromwell-road, South Kensington, S.W.7. (i) "A Quantitative Analysis of Large-Scale Patterns, with Special Regard to the Effect of Eddy Motion," by Mr. F. A. Berson ; and (ii) "On the Theory of Large-Scale Disturbances in a Two-Dimensional Baroclinic Equivalent of the Atmosphere," by Mr. P. D. Thompson.

ROYAL SOCIETY.—Thursday, June 18, 4.30 p.m., Royal Society's Apartments, Burlington House, Piccadilly, W.1. (i) "The Application of the Principles of Physical Optics to Crystal-Structure Determination," by Mr. A. W. Hanson, Mr. H. Lipson, and Mr. C. A. Taylor ; and (ii) "Photo-Ionisation and the Breakdown of Gases," by Mr. J. Dutton, Mr. S. C. Haydon, Mr. F. Llewellyn Jones and Mr. P. M. Davidson.

INSTITUTION OF PRODUCTION ENGINEERS.—*Wolverhampton Graduate Section :* Thursday, June 25, 7.30 p.m., Star and Garter Royal Hotel, Victoria-street, Wolverhampton. "British Watch and Clock Production," by Mr. R. Lenoir.

ROYAL SANITARY INSTITUTE.—Thursday, July 2, 10.15 a.m., Town Hall, Walsall. (i) "Land Use in Walsall, with Special Reference to Slum Clearance and Reclamation of Derelict Land," by Mr. M. E. Habershon ; on (ii) "Some Avenues to a Better Environent," by Mr. James Green.

AUTOMATIC CONTROL OF GAS PRODUCERS.

A SYSTEM for automatically regulating the input of air, steam and coal in gas-producer plants, in order to control the quality of the gas produced more efficiently than is possible under manual control, has been developed recently by Messrs. George Kent, Limited, Luton, Bedfordshire. In this scheme, the air intake is controlled by the gas off-take pressure, the steam input by the blast saturation temperature, and the coal feed by a regulator actuated partly by the producer load and partly by the gas off-take temperature. In the past, considerable difficulties have been encountered in controlling the gas off-take temperature, but these problems have now been solved by development work undertaken by George Kent, Limited, in conjunction with the British Coal Utilisation Research Association. As a result of controlling the coal feed, a deeper fuel bed can be employed, leading to a greater consistency in the quality of the gas, since the danger of tar deposition in the gas mains due to a fall in gas temperature is eliminated.

In a typical installation with a steam jet-blast injector, the gas pressure is detected in the gas off-take duct and is measured by a low-range pressure meter controlling a two-term pneumatic controller. The control signal from the latter is fed to a diaphragm-operated control valve in the steam main to the blast injector. The temperature of the blast is detected by a mercury-in-steel thermometer located under the blast hood, and is measured by a temperature-recorder containing a proportional pneumatic controller, the signal from which controls a diaphragm-operated control valve in the steam by-pass round the blast injector. The gas off-take temperature is detected by a thermocouple in the gas off-take duct, and is measured by a potentiometric temperature recorder containing a three-term pneumatic controller. The output signal from the temperature controller is added to that generated by a load-signal transmitter, comprising a pneumatic unit installed in a steam meter which measures the pressure of the steam at the inlet to the blast injector of the producer. The combined control signal is fed through a differentiating relay to a standard Kent power cylinder controlling the coal-feed regulator. The new control system is particularly useful in installations subject to considerable load variations, such as those associated with open-hearth furnaces in unit installations.

PERSONAL.

Following the death of LORD ABERCONWAY, C.B.E., the board of Westland Aircraft Ltd., have elected MR. ERIC MENSFORTH, C.B.E., formerly vice-chairman, to be chairman, and LORD ABERCONWAY (formerly the Hon. Charles McLaren) to be deputy chairman. The board of Wickman Ltd., have elected MR. S. W. RAWSON to be chairman and LORD ABERCONWAY to be deputy chairman.

SIR WILLIAM STANIER, F.R.S., has accepted an invitation to join the board of Brynmawr Rubber Ltd., Brynmawr, South Wales.

LORD BAILLIEU has been elected an honorary member of the Institution of Mining and Metallurgy in recognition of his services as chairman of the Empire Council of Mining and Metallurgical Institutions.

LT.-COL. R. F. GALBRAITH, R.E., M.C., B.Sc.(Eng.), A.M.I.C.E., has been elected President of the Institution of Structural Engineers, 11, Upper Belgrave-street, London, S.W.1, for the session 1953-54.

MR. WALTER C. PUCKEY, M.I.P.E., F.I.I.A., has been elected President of the Institution of Production Engineers, 36, Portman-square, London, W.1, for the session 1953-54.

MR. G. A. COOMBE, M.C., has been elected President of the Royal Institution of Chartered Surveyors, 12, Great George-street, London, S.W.1, for the session 1953-54.

DR. C. SYKES, F.I.M., F.R.S., has been re-elected President of the Institute of Physics, 47, Belgrave-square, London, S.W.1. PROFESSOR A. M. TYNDALL, C.B.E., F.R.S., has been elected an Honorary Fellow.

MR. G. W. STALLIBRASS, O.B.E., A.R.Ae.S., has been appointed director of navigational services (aerodromes), Ministry of Civil Aviation, Ariel House, Theobald's-road, London, W.C.1, as from June 8, in succession to MR. W. M. HARGREAVES, C.B.E., A.F.R.Ae.S., who has been appointed divisional controller, Northern Division.

MR. C. ROBSON, a director of Ashmore, Benson, Pease and Co. Ltd., Stockton-on-Tees, has been appointed chairman of the Tees-side Productivity Committee. MR. R. NICHOLSON, secretary of the Tees committee of the Confederation of Shipbuilding and Engineering Unions, has been made secretary.

MR. T. H. MOFFAT, deputy chief regional officer, British Railways, Scottish Region, has retired after 51 years of service.

MR. R. C. WORSTER, who has been a member of the research staff of the British Hydromechanics Research Association since its formation, has been appointed deputy director of research.

MR. J. F. A. BAKER, M.I.C.E., A.M.I.Mun.E., A.M.Inst.T., at present divisional road engineer, Ministry of Transport, for the Wales and Monmouthshire division, is to be deputy chief engineer (civil engineering) in succession to MR. R. J. SAMUEL, C.B.E., B.Sc.(Eng.), M.I.C.E., who is retiring on September 30. MR. L. CLEAVER, O.B.E., B.Sc., A.M.I.C.E., will succeed Mr. Baker in Wales and Monmouthshire. MR. T. E. HUTTON, B.Sc., M.I.C.E., A.M.I.Mun.E., will become divisional road engineer, South Western Division, in succession to MR. J. G. PIDGEON, M.I.C.E., who is retiring on July 17. Mr. Hutton's post as assistant chief engineer at headquarters will be filled by the promotion of MR. V. H. HAYNES, A.M.I.C.E., at present senior engineer at headquarters.

MR. G. W. HESLETT, manager, pump department, Hathorn, Davey & Co. Ltd., 31, Bedford-square, London, W.C.1, has been made a director.

MR. S. T. BAKER, technical representative of the Vacuum Oil Co. Ltd., has retired after 33 years of service. His successor is MR. W. H. DEFFER.

MR. W. SIMPSON, A.I.E.E., M.Inst.F., generation engineer (operation), S.W. Scotland Division, British Electricity Authority, has been appointed chief generation engineer (operation) of the Division, in succession to MR. W. MCFARLANE, who recently retired.

MR. G. J. MCDONALD, B.Sc., A.M.I.E.E., deputy technical manager, Marconi International Marine Communication Co. Ltd., Chelmsford, Essex, has now succeeded the late MR. F. P. BEST as technical manager.

MR. N. A. JENKINSON has been appointed London manager of the crane department of Babcock and Wilcox Ltd., on the retirement of MR. A. MERRY.

MR. B. H. HOLLAND, M.Sc., of the University of Leeds, has been awarded the Institute of Fuel students' medal and prize for 1952.

MR. R. W. M. MACALPINE, A.M.I.E.E., has been appointed assistant manager, London district office, British Thomson-Houston Co. Ltd., Rugby.

MR. G. F. SARGENT, late of Cyc-Arc Ltd., has been appointed buyer to K. D. G. Instruments Ltd., and Stow & Partners Ltd., Purley-way, Croydon.

CLARKSON (ENGINEERS) LTD., Nuneaton, have removed their London office and showroom to 124, Hammersmith-road, W.6. (Telephones : RIVerside 6645 and 1815.)

THE CONTINUOUS PRODUCTION OF TIMBER BOARD.

VERE ENGINEERING CO., LTD., MARKS TEY, ESSEX.

(*For Description, see Page* 748.)

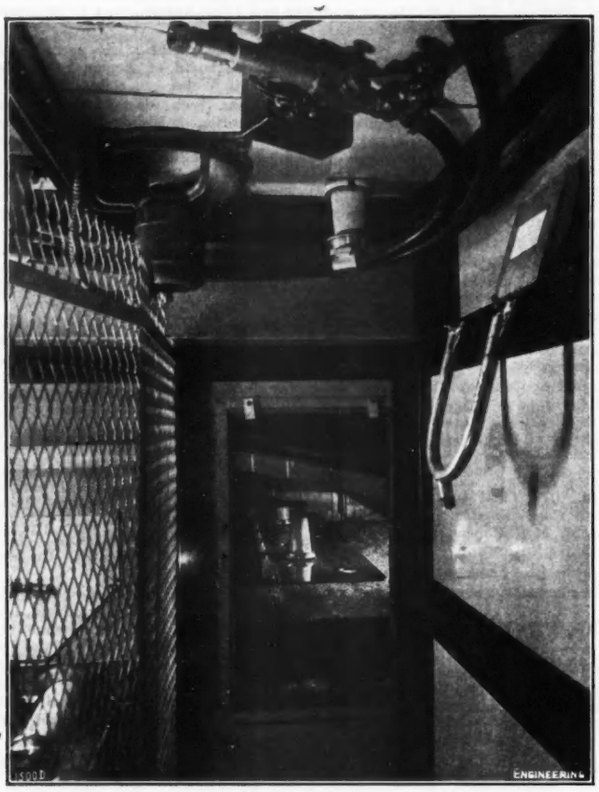


FIG. 4. HIGH-FREQUENCY HEATING UNIT.

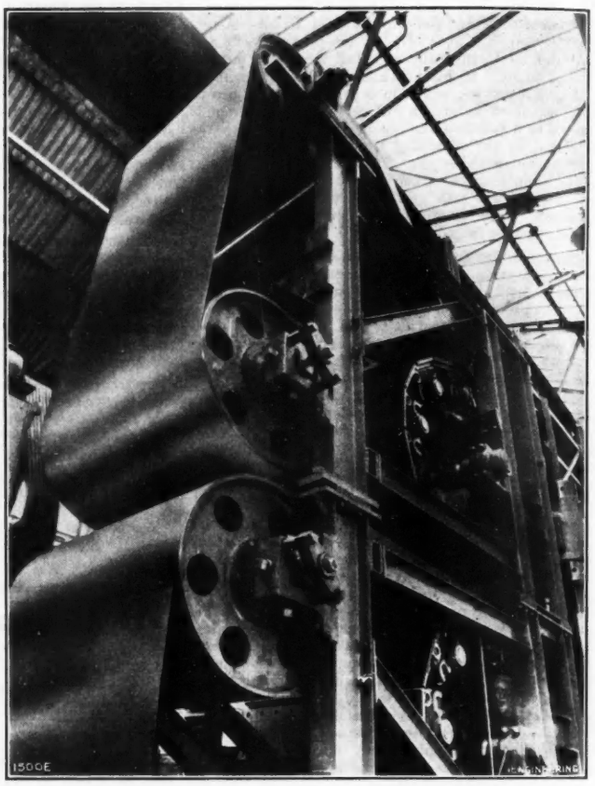


FIG. 5. STEEL FACING BANDS.

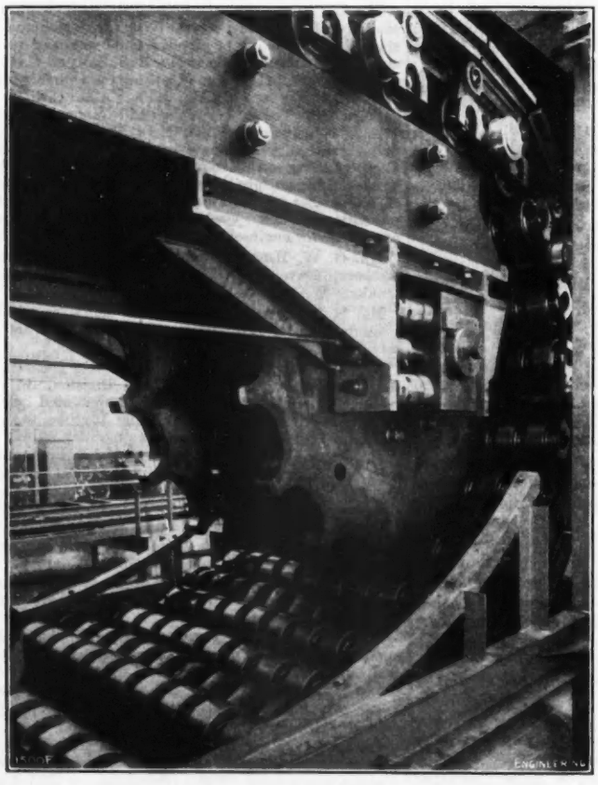


FIG. 6. PLATEN CHAINS.

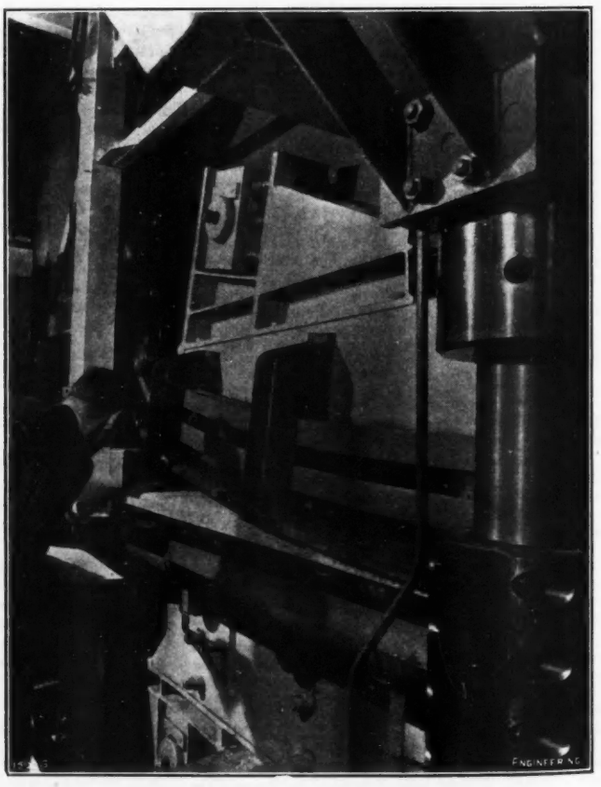


FIG. 7. RAW MATERIALS ENTERING PRESS.

ENGINEERING

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TEMPLE BAR 3663 and 3664.

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For Canada	£5 5 0

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ADVERTISEMENT RATES.

Terms for displayed advertisements can be obtained on application to the Manager. The pages are 12 in. deep and 9 in. wide, divisible into four columns 2¼ in. wide. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

The charge for advertisements classified under the headings of "Appointments Open," "Situations Wanted," "Tenders," etc., is 10*s*. for the first four lines or under, and 2*s*. 6*d*. per line up to one inch. The line averages six words and when an advertisement measures an inch or more, the charge is 30*s*. per inch. If use is made of a box number the extra charge is 1*s*. per insertion, with the exception of advertisements appearing under "Situations Wanted." Series discounts for all classified advertisements can be obtained at the following rates:—5 per cent. for six; 12½ per cent. for thirteen; 25 per cent. for twenty-six; and 33⅓ per cent. for fifty-two insertions.

TIME FOR RECEIPT OF ADVERTISEMENTS.

Classified advertisements intended for insertion in the current week's issue must be received not later than first post Monday.

"Copy" instructions and alterations to standing advertisements for display announcements must be received 16 days previous to the date of publication, otherwise it may be impossible to submit proofs for approval.

The Proprietors will not hold themselves responsible for advertisers' blocks left in their possession for more than two years.

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PLATE.

Plate XXII.—YORK RIVER BRIDGE, VIRGINIA, U.S.A.

ENGINEERING

FRIDAY, JUNE 12, 1953.

VOL. 175. No. 4559.

DISTANT SIGNAL.

THE main-line railways have one of the largest engineering organisations in the country. With the passing of the recent Transport Act, the future of that organisation is in the melting pot. There is time now for a full discussion of the nature of the decentralised system which the Government wish to be devised for the railways as a whole, and there is time for engineers to debate the problem in its engineering aspects. A leading article in this journal last week pointed to some of the fundamental issues, but as the outcome is likely to affect the future of certain sections of the engineering industry, as well as the engineering departments of the railways themselves, the subject is worthy of further consideration.

It would be folly to assume that the Government propose to sweep away in its entirety the system which has produced so many technical improvements in the few years since the railways were nationalised. Indeed, the Minister of Transport has given an assurance that, where central control has proved to be beneficial, it should not be disturbed. Since it is in engineering matters that central control has most evidently been fruitful, it is possible, though by no means certain, that an endeavour will be made to continue and expand the good work already achieved. The kind of reorganisation proposed by the British Transport Commission—on whom the onus of working out a scheme rests—will depend on the kind of reorganisation proposed for other departments of British Railways, but they will not necessarily be similar. The civil, mechanical and electrical branches of engineering on the railways are a service within a service, and it is in that light that their future should be planned. Too often in discussions on the railways sentiment masquerades as expert knowledge. Whatever changes are put into effect in the next year or two, there will be no shortage of critics, but as there are still men who speak nostalgically of pre-grouping days, and even wish to see a return to the colourful variety of the old companies, the words of the critics will have to be examined with circumspection.

Most of the technical developments which have taken place in the past four and a half years could not have been achieved by the four former railway companies. Engineers representing each region have met and formulated economical policies for a wide range of problems, including questions of administration and such unspectacular matters as the use and range of non-ferrous alloys, as well as the more publicised policy of standard locomotive designs. So far as railway engineering is concerned, there has been no question of a dictatorship, imposing unrealistic decisions on a reluctant staff. The decisions have been reached mainly by a process of examination and discussion; the best practices have come to the surface and been adopted. The economies which have resulted amount to millions of pounds sterling, and if the new policies are allowed to continue they will pay an increasing dividend in years to come.

The opposite side of the picture, however, is less easily discerned. If standardisation—to take the most notable factor—leads to economies, may it not also result in stagnation? Have the Railway Executive, by the very act of pooling the experience and wisdom of the former railway companies, shut themselves off from the possibility of a variety of experience and wisdom in the future? It may be that, in the course of time, a homogeneous organisation such as British Railways will beget mediocrity in technical development, but there is no innate reason why it should. For years, the railways of this country have been restricted in the money they could spend on long-term scientific investigations, but even the national poverty of the post-war years has not prevented the nationalised system from undertaking some bold work in this direction. The engineering staff of the Railway Executive is relatively small. Decentralisation has perforce been practised; perhaps it can be continued, with modifications to conform with the re-organisation of other departments.

The issue hinges on the scope there is for imaginative and startling progress. It is not belittling railway engineering to remark that the scope is limited. When an intelligent layman protests that standardisation will lead to stagnation his views are coloured by the evidence around him of what science and engineering have achieved in aircraft, atomic energy and other manifestations of research. But with the steam locomotive, at least, we are dealing with a venerable machine that is approaching the asymptote of development. It is extremely unlikely that there is a major invention still to be found, as the history of trial and error in locomotive design shows. Carriages and wagons, also, are not susceptible to revolutionary improvements in design. British Railways, without using light alloys, have developed carriages which compare favourably, in respect of weight per passenger and of strength, with any in the world.

Improvements in motive power are the main hope of the future. Extensive electrification is certainly the most practicable course, but as the Government have been unable to permit sufficient capital expenditure even for essential and continuing work, the prospect is not encouraging. Steady progress has been maintained with the introduction of Diesel-electric locomotives, and already it has raised a point of engineering policy which would also occur with further electrification. An article elsewhere in this issue describes a new design of Diesel-electric shunting locomotive. Following

accepted practice on British Railways, the mechanical components have been designed and built by the railway, and the Diesel engine and electrical equipment have been supplied by an outside firm. Interest attaches to these locomotives, however because provision has been made in the design for using Diesel engines and electrical equipment from more than one maker—and thus of more than one design. There is no risk here of standardisation leading to stagnation: that part of the design which is based largely on long experience is standardised, except for a few details which must be varied to suit different proprietary designs, but that part which may be expected to develop more noticeably, stimulated by competition among outside firms, has been left open to change. No doubt the time will come, with Diesel-electric power units as with the steam engine, when it will be economic, from a railway point of view, to do away with variety in design and settle down to standard types, allowing occasional improvements which can be shown to justify the interruption they cause, but that time has not arrived for Diesel, electric or gas-turbine locomotives.

The development of these newer forms of motive power is carried out mainly by industry, and it is therefore not likely to be retarded by a central railway authority which maintains a reasonably experimental outlook. A new situation will arise, however, when the nation's finances permit the railways to embark on a major change in motive-power policy. The railway will depend for their locomotive designs on industrial firms, and even a single railway authority for the whole country will have difficulty in preserving a semblance of standardisation, as the design of the new Diesel-electric shunting locomotive has already illustrated. It may be argued, of course, that under these conditions it would be preferable to have several railway authorities rather than one, on the ground that competition among users is as important as competition among producers. Experience to date suggests that a single authority—namely, the Railway Executive—is well able to foster competition in civil, mechanical and electrical engineering.

In the final analysis, however, the bounds set to freedom of this kind must be regulated by the needs of the commercial and operating departments of the railways. Their needs are analogous to those of an army: in both cases the equipment must be so standardised that flexibility of operation is assured. In an army, standardisation extends to the size and "establishments" of regiments, as well as to the equipment, and it is so vital to successful operations that in the case of tanks, for example, one, or at the most two, designs are held to be sufficient. On the railways, the operational task is not so variable or unpredictable; nevertheless, traffic fluctuates, a whole class of locomotives may have to be withdrawn temporarily because of a suspected fault, and national events, planned and unplanned, demand special and emergency action. These circumstances are overcome efficiently only if rolling stock can be switched quickly from one area to another. Flexibility of operation demands standardisation of equipment. The scheme to be worked out by the British Transport Commission, therefore, should recognise these differing characteristics of the several railway departments. Decentralisation is the worthy intention of the Transport Act, but it must not lead to a wholesale change of railway organisation; too much has been achieved in the engineering departments, whatever the shortcomings in other aspects of operation of the nationalised railways, for it to be squandered by doctrinaire changes. The Act is a distant signal in the progress of the main-line railways; it demands extra vigilance until the green light of the Commission's scheme is seen. After that, the road must be clear.

NOTES.

SUMMER SCHOOL IN CIVIL ENGINEERING.

SUBJECT to sufficient support being forthcoming, it is proposed to hold a summer school in civil engineering at the University of Birmingham between July 13 and July 18 next. The course, which will be very intensive, will take the form of lectures followed by discussions and practical demonstrations and is intended for senior engineering executives. With 35 members, a fee of 7*l.* per person would be charged; smaller numbers would involve an adjustment of the fees. The maximum attendance would be restricted to 40. Limited residence could be provided in the University hostels. The proposed syllabus is divided into three parts: structural theory and analysis; concrete technology; and soil mechanics. Topics to be discussed in structural theory will include analytical methods of solving rigid-jointed frames, the plastic design of steel subjects and the use of non-ferrous metals for structural purposes. One of the lectures is to be devoted to an introduction to modern mathematical methods, such as the solution of structural problems by finite differences, relaxation methods, dimensional analysis and statistical analysis. Of the three lectures on concrete technology, two are to be devoted to the elements of prestressed concrete; the third lecture will be concerned with recent advances in concrete technology. In respect of soil mechanics, six lectures will be given on each of the recognised sub-sections of the subject. In general, précis notes of each lecture will be made available but members will be expected to supplement these by their own notes.

PRESSED-METAL INDUSTRY.

The British Productivity Council recently issued the report of a team of 15 Americans who visited this country in 1951 under the auspices of the Anglo-American Council of Productivity. It deals with the British pressed metal industry. The report says that the difference in philosophy, both economically and politically, between the two countries, and the fact that Britain has been through two devastating wars in 25 years make impossible a direct comparison between British and American methods and equipment. Contrary to American practice, the team observed that time and motion studies are made, with the emphasis on the time, and little, if any, thought is paid to the motion aspect, and they thought that more work simplification studies could be undertaken. They were unable to find any indication that the British executive had ever tried to take a firm stand with customers on the subject of standardisation. In general, they thought there was a lack of "cost-consciousness" by comparison with their own country and departmental budgets or foreman's budgets were rare; they claimed that the efficiency of many large companies in the United States was determined by such cost-consciousness. The team was impressed by the "Roto-dip" process for coating automobile bodies, which had not been seen in the United States. In particular they thought there was a need for a freer and more organised interchange of production and technical information by the companies within this country. On the subject of safety they felt that more energy should be devoted towards making the worker safety-conscious and less towards the construction of guards which hindered the work in hand. A tribute was paid to the relationships between employers and the unions. In management the team found a need for recognition and improvement of materials handling methods, improved planning and plant layout, greater standardisation, and better co-operation between safety engineers and production personnel. As far as employees were concerned the team hoped to see an interchange of men sponsored by the industry between the two countries so that the British worker could obtain a clearer insight and understanding of American enthusiasm, and he, in return, could impart to the American the British pride in craftsmanship.

COMMERCE AND INDUSTRY EXHIBITION AT INDIA HOUSE.

An exhibition which displays both the traditional and the present-day utilitarian manufactures of India, supported by a section devoted to photographs of several processes and activities, a tourist bureau and numerous graphs giving statistical information, is now open to the public at India House, Aldwych, London. The population of India is given as 357 millions at the time of the decennial census of 1951, and it will now have passed the 360 million mark; 82 per cent. of the pre-partition population of the sub-continent remained with India, but only 69 per cent. of the irrigated area, it is stated, so making the new India largely dependent on imported food. There are 60 irrigation projects in hand, designed to increase the irrigated area from 50 to 75 million acres and the total output of food grains from 53 to 62 million tons a year. Some 400*l.* million is being spent on irrigation and power projects, such as the Mangal-Bhakra scheme, on which 40*l.* million has already been spent. A number of photographs of the Mangal-Bhakra scheme, taken by Rooster Publicity, Limited, illustrate the progress to date, while other photographs taken by this organisation ably illustrate gold mining, coal mining, shipbuilding and other activities. As regards shipbuilding, photographs show the yards at Visagapatam, where three 8,000-ton vessels are building. Other photographs show the Chittaranjan locomotive factory, built at a cost of 13*l.* million and designed to meet half of India's locomotive requirements; in 1951-52, this factory turned out 58 locomotives, mostly of the 2-8-2 type, and 643 coaches, for 5 ft. 6 in. and metre gauge tracks. Other photographs illustrate the Sindri Fertiliser factory, conceived during the war and opened in 1951 to produce over 1,000 tons of ammonium sulphate a day; this factory, the largest of its kind in Asia, cost 17*l.* million. Also illustrated are the assembly of the products of the Standard Motor Company, Limited, Coventry, and the assembly of eight-seater gliders. Among the physical exhibits are examples of traditional Benares silks and ware, carpets from Agra and Mirzapore, and a selection of sports goods, including cricket bats of Kashmir willow, manufactured by the Government Sports Goods factory.

POWDER-METALLURGY EXHIBITION.

A comprehensive selection of sintered parts currently used in many engineering industries was on view earlier this week at a three-day exhibition arranged by Powder Metallurgy Limited, 59-62, High Holborn, London, W.C.1, at the offices of their parent company, Messrs. F. W. Berk and Company, Limited, Commonwealth House, 1-19, New Oxford-street, W.C.1. The exhibits comprised several hundreds of separate pieces received from over 30 firms and institutions and were representative of recent British, American and European achievements in powder metallurgy. Samples of the metal powders employed, including the new powdered alloys such as 18:8 stainless steel, manganese steel, Monel metal and Nimonic alloy, were on view. These, like the bronze, brass, zinc, tin, lead, white-metal, aluminium, sponge-iron, and nickel-silver powders, previously available, are manufactured by atomisation, usually in a protective atmosphere to prevent oxidation. Among the exhibits were examples of porous bronze and other alloy filters for chemicals and gases, and oil-retaining bronze and iron bearings. The close dimensional tolerances and smooth surfaces obtainable by powder metallurgy were shown by numerous gears and gear-wheel components, cams, brake and clutch-linings, cylindrical parts, discs, levers, and other articles used in clock-making, and in the production of such equipment as locks, calculating machines, cash registers and sewing and other machines for household use. A rather striking exhibit shown by the Atomic Energy Research Establishment, Harwell, was a beryllium tube extruded from material produced from powder in flake form. The tube was about 15 in. in length by 1¼ in. in outside diameter and 1 in. in bore diameter. One end had been machined to show the quality of the metal surface obtainable.

LETTER TO THE EDITOR.

CREEP PROPERTIES OF STEELS FOR POWER PLANTS.

TO THE EDITOR OF ENGINEERING.

SIR,—In the conclusions reached in the article "Creep Properties of Steels for Power Plants.—I," by Dr. A. E. Johnson and Mr. N. E. Frost, which appeared on pages 25 and 58 of the issues of ENGINEERING for January 2 and January 9, 1953, the authors express doubt of the validity of the analytical treatment proposed by Dr. R. W. Bailey for replacing stress and temperature peaks by an equivalent steady temperature. The authors discovered a large disparity between their experimental results and the analytical treatment, particularly in the case of the 0·17 per cent. carbon steel, where stress peaks occur at steady temperature.

The value of $\overline{\theta - \theta}$, the increase in the design temperature, above the steady rated temperature, which takes account of the pressure fluctuations, is given by the equation:

$$\overline{\theta - \theta} = \frac{1}{a} \log_e \{\alpha\, e^{a\,\delta\theta'} + (1 - \alpha\},$$

where

$$\delta\theta' = \frac{n}{a} \log_e \left(\frac{f'}{f}\right).$$

The values of n and a are both obtained from experimental data and will lead to some scatter of results when compared with creep-test data. The disparity mentioned above, however, is greater than would be expected from experimental error.

Although the authors stated that the value of n can only be treated as constant over a restricted range of variation, they only assigned one value to it, despite the fact that some of the stress fluctuations were as large as 50 per cent. In the last part of the article, published on page 249 of your issue of February 20, the authors suggest alternative analytical treatments which take into account the possible variation in the constants a and p with strain, while n is regarded throughout as being constant for each material.

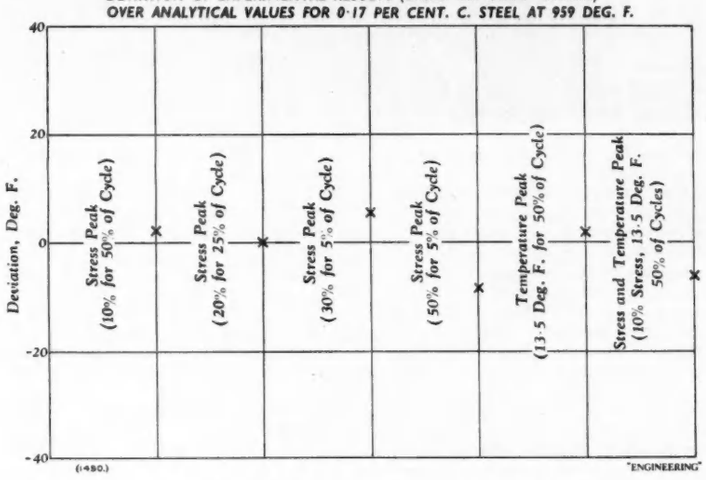
Our interpretation is that, since the value of n is largely independent of strain, the constant p will not enter into the Bailey analysis, because n itself is evaluated from specific strains. At the same time, experimental evidence suggests that a is fairly independent of stress, and we conclude therefore that the logical approach to the problem of stress and temperature peaks would be the employment of Dr. Bailey's method with a variable n.

Actually, n, though fairly independent of temperature, is extremely stress-dependent, and we suggest that the appropriate values should be taken when dealing with cases involving stress fluctuations. The variability of n with stress has been shown, for a number of materials, by Dr. Bailey in his paper "Steam Piping for High Pressures and High Temperatures" (*Proc. I.Mech.E.*, vol. 164, page 324 (1951)). It is significant, in the case of the carbon steel, that the difference between the experimental and analytical results increases as the stress variation increases. Values deduced from comprehensive creep data on two normalised carbon steels containing 0·135 per cent. C and 0·24 per cent. C gave the following variation of n with stress:

Stress, tons per square inch				
2	4	6	8	500 deg. to
5·2	9	12	15·7	550 deg. C.

Employing this relationship between stress and n, we have recalculated the values of equivalent steady temperatures, from the Bailey equations, and plotted from these the deviations from the experimental values based on creep strain in 300 hours. The result is shown herewith. The deviations are quite small and are, in fact, less in each case than those obtained by the authors for the 0·17 per cent. C steel. Some small deviations are to be expected from experimental error and from the fact that the values of n employed in the calculations may not exactly hold for this material.

DEVIATION OF EXPERIMENTAL RESULTS (BASED ON CREEP STRAIN) OVER ANALYTICAL VALUES FOR 0·17 PER CENT. C. STEEL AT 959 DEG. F.


40
20
0
-20
-40
Deviation, Deg. F.
Stress Peak (10% for 50% of Cycle)
Stress Peak (20% for 25% of Cycle)
Stress Peak (30% for 5% of Cycle)
Stress Peak (50% for 5% of Cycle)
Temperature Peak (13·5 Deg. F. for 50% of Cycle)
Stress and Temperature Peak (10% Stress, 13·5 Deg. F. 50% of Cycles)
(1480.)
"ENGINEERING"

A considerable reduction in the deviations also resulted from employing appropriate values of n in the case of the 0·5 per cent. Mo steel at 1,085 deg. F. and the 0·5 per cent. Mo, 0·23 per cent. Va steel at 1,103 deg. F., the largest errors encountered being + 5·7 deg. F. and — 3·4 deg. F., respectively. The authors conclude that the analytical treatment put forward by Dr. Bailey is not capable of adequately representing the experimental results, particularly at high stress peaks, and imply that this is because the convention of representing the high-stress peaks by equivalent temperature peaks is open to doubt. It is our opinion, however, that the tests demonstrate the validity of the method as a means of computing the effect of stress fluctuations on creep, providing the variation of n with stress is taken into account.

Yours faithfully,

JOHN H. M. DRAPER, B.Sc.Tech., A.M.I.Mech.E.
G. GOSLING, G.I.Mech.E.

Research Department,
Metropolitan-Vickers Electrical Company, Limited,
Trafford Park, Manchester, 17.
May 26, 1953.

THE GAUR STATION OF THE NORTH OF SCOTLAND HYDRO-ELECTRIC BOARD.—The Gaur hydro-electric station at Rannock, Perthshire, which forms part of the development of the North of Scotland Hydro-Electric Board in this area, is to be opened by the Prime Minister of Australia (the Rt. Hon. Gordon Menzies) on Saturday, June 20. The scheme includes a 50-ft. dam at the outlet of Loch Eigheach and a 6,000-kW station on the River Gaur, which flows into Loch Rannock. It will produce 17 million kilowatt-hours annually.

THE NEWCOMEN SOCIETY.

THE Newcomen Society, which exists "for the Study of the History of Engineering and Technology," held its summer meeting in Cambridge and district between May 27 and May 30. The members met on the evening of May 27 in the University Arms Hotel, which was the headquarters of the meeting, when a short address was given by Mr. L. E. Harris, A.M.I.Mech.E., on the history of the drainage of the Fens; the tercentenary of the final adjudication on the draining of the Great Level, Mr. Harris explained, occurred on March 26, 1953, and the meeting served to commemorate that event. On the following morning, therefore, the party left in motor coaches for Earith, at the head of the Bedford Rivers, cut by Cornelius Vermuyden in 1632 and 1652, respectively, proceeding by way of Ely and Littleport to Hilgay Bridge, on the Great Ouse. There they embarked in barges provided by the Great Ouse River Board and were towed down the river to Denver Sluice. This sluice was constructed about 1652, rebuilt by Labelye (the designer of the old Westminster Bridge on the River Thames) in 1750, and again rebuilt, by Sir John Rennie, in 1832.

After lunch in Ely, the party divided, the two sections visiting, in turn, Ely Cathedral and the Fen Office of the Great Ouse River Board; where, by courtesy of the Board's chief engineer, Mr. W. E. Doran, M.I.C.E., and under the guidance of Mr. F. C. Free, they were able to inspect a number of Seventeenth-Century maps, original documents, etc., concerning the activities of the Adventurers for the Draining of the Great Level. Some of the drawings bore the signatures of Thomas Telford (1757-1834) and of Sir John Rennie. On the return journey to Cambridge, a halt was made at the Stretham pumping station of the Waterbeach Level Drainage Commissioners, where they were received by the superintendent, Mr. C. O. Clarke. This engine, one of the earliest erected in the Fens for drainage purposes, was built by the Butterley Company and installed in 1831. It has a cylinder 39 in. bore and a stroke of 8 ft. and was used to drive a scoopwheel 37 ft. in diameter and 29 in. wide. At a speed of 12 to 15 strokes a minute, it raised about 130 tons of water a minute. The engine was last used in 1937.

In the evening of May 28, the annual dinner of the Society was held in the University Arms Hotel, the chair being taken by the President, Mr. J. Foster Petree, M.I.Mech.E., who conveyed to the members the greetings of the American affiliated Newcomen Society, on whose invitation he had recently visited the United States and Canada. The principal guests at the dinner were Dr. J. F. Baker, Professor of Mechanical Sciences in the University of Cambridge, and Mr. W. E. Doran, of the Great Ouse River Board, with their ladies. Both Professor Baker and Mr. Doran responded to the toast of "The Guests," proposed by Dr. A. P. Thurston, a past President of the Society.

The proceedings on May 29 began with a visit to the Cheddars-lane pumping station of the city of Cambridge, by invitation of the City Engineer, Mr. T. V. Burrows, A.M.I.C.E. This station contains two fine examples of the Davey horizontal differential pumping engine, installed in 1894. The party was received by Mr. W. T. Barrett, the superintendent of the station. The engines run at 10 to 12 strokes a minute and have a maximum duty of about 200,000 gallons an hour, delivered through two miles of 24-in. main.

There followed a visit to the tidal model of the River Great Ouse, the working of which was demonstrated by Mr. W. E. Doran. At present, it is being used to investigate the effect of a high river discharge on the navigable channels in the estuary of the Wash, and especially those at King's Lynn. A detailed model of the King's Lynn channels was also seen; this is 185 ft. long, corresponding to a full size of about three miles. The main model has been used to examine the effect of the proposed new drainage channel, which, with a surface width of 300 ft., would link up the rivers Lark, Little Ouse and Wissey, the overflowing of which caused such serious floods in 1947. The rest of the morning was occupied by a visit to the Fleam Dyke pumping

station of the Cambridge University and Town Waterworks Company (by courtesy of Mr. P. Porteous, M.I.C.E., chief engineer and managing director), in which are two Hathorn Davey horizontal tandem engines, each driving two pumps through bell-crank levers. These engines have cylinders 23 in. and 51 in. in diameter by 4 ft. stroke, taking steam at 120 lb. per square inch, superheated to 475 deg. F., from three John Thompson Lancashire boilers. Incidental exhibits of historical interest were a section of 6-in. cast-iron main, dating from 1842, and some bronze plug cocks, probably of the early Eighteenth Century, taken from pipelines formerly supplied from Hobson's Brook.

After lunch, the party again divided, one section visiting the County Folk Museum, under the guidance of the curator, Miss Porter, and the other the Whipple Museum of early scientific and astronomical instruments, where they were received by Dr. A. R. Hall. The Whipple Museum was fully described in the 159th volume of ENGINEERING, in the issues of March 2 and 23, 1945, at the time of its opening; the contents were the gift of Mr. R. S. Whipple, of the Cambridge Instrument Company. In the afternoon, by invitation of Professor J. F. Baker, the members visited the new engineering laboratories of the University of Cambridge; these also were described recently in ENGINEERING, in our issue of November 21, 1952 (vol. 174, page 669). After a tour of the laboratories, an address on "The Early History of the Teaching of Engineering in Cambridge" was delivered by Mr. E. G. Sterland, with the aid of a number of original demonstration models, mostly representing various forms of gearing, made by Robert Willis (1800-1875).

DIESEL-ELECTRIC SHUNTING LOCOMOTIVES FOR BRITISH RAILWAYS.

A NEW British Railways' standard design of 0-6-0 Diesel-electric locomotive, of which some have already been delivered for service, generally follows the more recent regional designs of Diesel-electric shunter, with nose-suspended traction motors and double-reduction gears, but certain modifications have been made to suit operating requirements and to give the locomotives the widest possible route availability. In addition, provision has been made for using Diesel engines and electrical equipment from a number of manufacturers with a minimum of alterations to the main locomotive structure. The engines have been designed and built at Derby to the requirements of Mr. R. A. Riddles, member for mechanical and electrical engineering, Railway Executive. The power is 400 brake horse-power, the tractive effort 35,000 lb., the adhesion factor 3·13, the braking proportion 66·2 per cent., the minimum radius of curve (with specified gauge widening) 3½ chains, the total weight, light, 45 tons, and, in working order, 49 tons. One of the first of the class is illustrated above.

DIESEL ENGINE AND GENERATOR.

The Diesel engine used in locomotives now being built is the English Electric Company's type 6KT, with six cylinders, 10-in. bore and 12-in. stroke, giving a maximum output of 400 brake horse-power at 680 r.p.m. The governed speed of the engine is variable between 300 and 680 r.p.m., while producing full torque. The cylinder liners are of the wet type and the engine has a wet sump. A hand-operated lubricating priming pump is provided to ensure adequate lubrication before the engine fires. Exhaust gases are taken through a water-cooled manifold to a silencer box mounted behind the top radiator header. Filters are provided for the air, fuel-oil and lubricating-oil systems. The radiator has elements of the Serck type, seven for water and four for lubricating oil. Cooling-water circulation is by means of an engine-driven centrifugal pump; an induced-draught fan, belt-driven from the engine crankshaft, draws air through the radiator. Hand-operated shutters supplied by the Spiral Tube and Components Company, Limited, Derby, are fitted for controlling the cooling-water temperature, and adequate water capacity is provided in the header tanks for evaporation losses, etc. Low-level filler pipes of the carriage type are fitted. Main and service fuel tanks (585 and 83 gallons, respectively) are of welded construction and are of sufficient capacity to provide for 10 to 15 days shunting before re-fuelling. A Bayham dial contents gauge is fitted to each tank, and filling is through a self-sealing Lockheed-Avery coupling. A hand-operated transfer pump is fitted in the cab for daily filling of the service tank.

DIESEL-ELECTRIC SHUNTING LOCOMOTIVE.

The main generator is directly coupled and rigidly attached to the engine, with which it forms a unit carried on a three-point mounting on the locomotive frames. It is a self-ventilated separately-excited direct-current machine with six poles and interpoles, and is continuously rated at 441 amperes and 430 volts at 680 r.p.m. A separate starting winding is provided for motoring the generator from the battery to start the Diesel engine. An auxiliary generator, mounted above and belt-driven from the main generator shaft, provides current for battery-charging, lighting, control, and compressor and exhauster motors. It is continuously rated at 13·5 kW at 90 volts.

MOTORS AND CONTROL GEAR.

Two traction motors are provided, on the leading and trailing coupled axles, and these are of the English Electric Company's standard design, with roller bearings on the armature shaft. The double-reduction gearing gives a ratio of 23·9 : 1 to the road wheels. The motors are force-ventilated from a fan driven from the main generator shaft, and are each continuously rated at 280 amperes and 400 volts. Engine speed, generator output, and thus locomotive speed and power, are controlled from a cubicle in the driver's cab. The controls are duplicated on either side of the cubicle and consist of reverser and controller handles, which are interlocked to prevent faulty operation. A master switch, with detachable key, is mounted on the right-hand side of the cubicle, and meters and gauges are mounted on an inclined panel above the cubicle, visible from either driving position. A deadman's pedal device prevents power being applied to the locomotive unless the pedal is depressed, and a short delay action enables the driver to cross the cab to the opposite position before the device operates. A locomotive speed indicator, with the main ammeter, is mounted on a swivel bracket above the control cubicle. The main generator-field resistances are frame-mounted in the main generator compartment. On the back of the cab is fitted a carbon-pile voltage regulator, supplied by Newton Brothers (Derby), Limited, which maintains 90 volts across the battery, control and lighting circuits, and for the compressor and exhauster motors. The battery consists of 40 lead-acid cells, made by the D.P. Battery Company, Limited, Bakewell, Derbyshire, and having a capacity of 108 ampere-hours. Five four-cell monobloc units are housed in each of two battery boxes, mounted one on each side of the locomotive superstructure.

MECHANICAL COMPONENTS.

The main frames are of 1-in. plate and are arranged outside the wheels. They are rigidly stayed by front and rear drag-boxes of pressed and riveted construction, and by intermediate stretchers and the engine and generator support. Rubber pads are fitted under the feet of the power-unit pedestals. The coupled wheels are 4 ft. 6 in. in diameter. This size has been dictated by the need for the coupling rods and cranks to come within the "Ll" rolling-stock gauge of British Railways. Axleboxes are of cast steel, with pressed-in horse-shoe brasses lined with whitemetal, and work in cast-steel guides. The overhead laminated springs are of carbon steel, with screwed adjustable links. A platform is provided at the front end on both sides, to accommodate the shunter when riding short distances. The total wheelbase is 11 ft. 6 in.

The engine-housing framework is welded from rolled-steel sections, with ample access doors to the power unit. In addition, the roof over the engine can slide rearwards to enable top maintenance to be carried out readily. The cab is fully enclosed, and drop lights are provided in the side windows. In addition, the front and rear windows are hinged for cleaning purposes. Heating is effected by tubular radiators taking hot water from the engine-cooling system. An adjustable upholstered stool is provided each side for the driver, and an electric food warmer is also fitted for his use. Electric lighting is provided in the cab and there are electric marker lights fitted at the front and rear of the engine to enable the standard code indication to be displayed. Four Kidde carbon-dioxide fire extinguishers are carried in the cab.

The locomotive is equipped with a system of straight air brakes, with controls for the vacuum-operated brakes on freight trains. The air brake is controlled by a self-lapping brake valve, used in isolation for normal shunting work, but when handling a vacuum-fitted train the vacuum brake controls are used, giving the normal automatic action in case of a breakaway, and controlling the application of the locomotive air brake, in synchronism with the vacuum brake, through a proportional valve. Compressed air for the locomotive brakes, the sanding gear and whistle is maintained by a motor-driven compressor governed to maintain a reservoir pressure of 65 to 85 lb. per square inch. Two motor-

THE NESTON WORKS OF MORGAN REFRACTORIES, LTD.

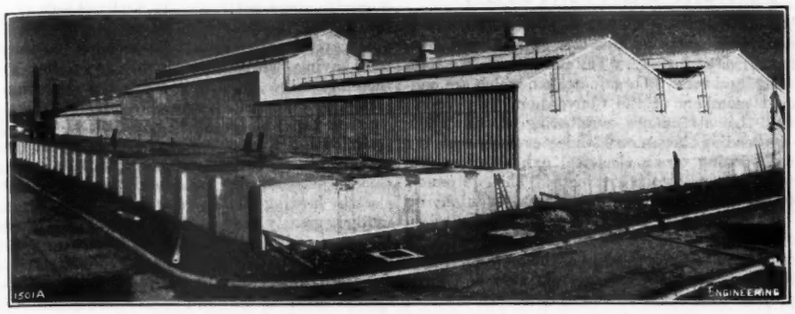


FIG. 1. EXTERIOR VIEW OF BRICK-MAKING SHOP.

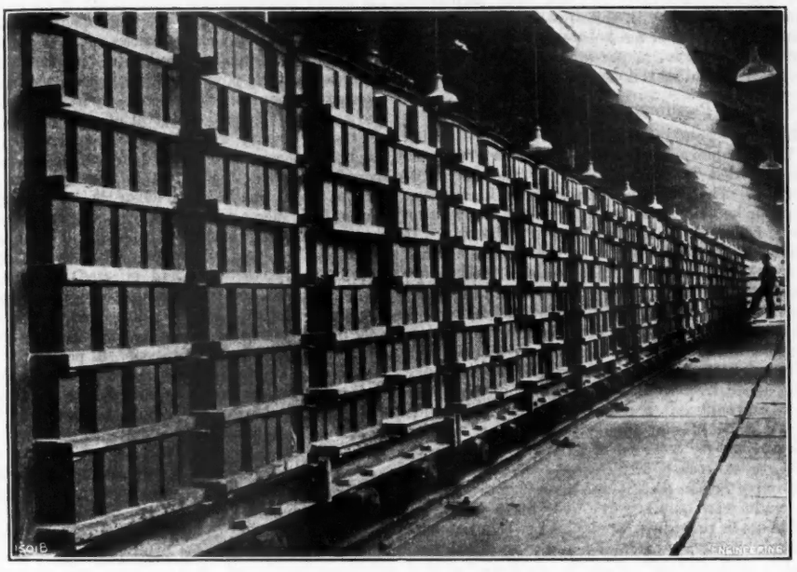


FIG. 2. REFRACTORY BRICKS BEFORE ENTERING DRIER.

driven three-cylinder exhausters, mounted on bedplates incorporating silencers on each side of the engine housing near the front of the locomotive, maintain the vacuum in the train pipe. These have two running speeds: 730 r.p.m. for normal maintaining and 950 r.p.m. for effecting brake release, the fast speed being brought in by depression of a trigger on the vacuum-brake valve handle. Application of the vacuum brakes on the train isolates the exhausters from the train pipe by means of electrical contacts on the brake-valve spindle and an electric exhauster cut-out valve. Both air and vacuum brake valves can be operated from either side of the cab. Two 13-in. diameter by 6½-in. stroke air-brake cylinders apply two articulated brake blocks to each wheel through fully-compensated brake rigging. The Westinghouse Brake and Signal Company's "Weslak" automatic slack adjusters are fitted. The brake rigging is grease-lubricated. Ancillaries using compressed air are the whistle, sanding (with provision for both directions of travel), and fuel-raising connection. Gears for the locomotives are supplied by Alfred Wiseman and Company, Birmingham, and instruments by the Record Electrical Company, Limited, Altrincham.

Locomotives built to this design are being allocated as follows: Nos. 13000-13004, Western Region; 13005-13009, Scottish Region; 13010-13014, Southern Region; 13015-13024, London Midland Region.

"SHELL AND THE GAS TURBINE" EXHIBITION.—An exhibition illustrating the part played by the Shell Petroleum Co., Ltd., in the development of the gas turbine will be open to the public from June 3 to August 31, from 11 a.m. to 7 p.m. daily, in the public enclosure at Northolt Airport.

THE NESTON WORKS OF MORGAN REFRACTORIES, LIMITED.

IN 1948, the Morgan Crucible Company, Limited, Battersea Church-road, London, S.W.11, a firm which has been manufacturing specialised refractories for upwards of 60 years, formed a wholly-owned subsidiary company, Morgan Refractories, Limited, to produce, in bulk, industrial refractories, especially those calculated materially to assist in achieving fuel economy. The new subsidiary company also took over the interests of the parent company in the associated concerns: Coupe and Tidman, Limited, Pontypridd, Glamorgan; the Douglas Firebrick Company, Limited, Dalry, Ayrshire; and the Whitrigg Fireclay Company, Limited, Glasgow. In the interests of manufacturing efficiency and to allow for future expansion it was decided to remove Morgan Refractories, Limited, from Battersea and to rehouse the works in modern buildings in a new locality. This has now been done and new factory premises have been built on a site, 43 acres in area, in Liverpool-road, Neston, Wirral, Cheshire, some 10 to 12 miles from Birkenhead Docks. The London Midland Region railway line, with over half-a-mile of sidings, forms the western boundary of the site and Liverpool-road the southern boundary. At present, only the western third of the site, that alongside the railway, has been developed, but large extensions are under consideration, some of which are at the drawing-board stage.

The refractories now being manufactured at Neston can be divided into four broad groups. In the first is the MR series, comprising a full range of stabilised aluminous refractories containing a minimum of 43 per cent. of alumina. The second group consists of the MI series of insulating refractories for high-temperature service. The third group includes special refractories of clay, sillimanite, bauxite, fused alumina, silicon carbide, magnesite and pure oxides, previously made at the Battersea Works, such as furnace shapes, tubing, crucibles, muffles, and cupels. In the fourth group are classed refractory and insulating concretes, mouldable refractories and refractory cements. The framework of the Neston factory buildings is of reinforced concrete and their external appearance is shown in Fig. 1, on this page. Special care has been taken, in the internal design, to prevent contamination. All fittings above ground level are of aluminium and ledges which might hold and shed dust have been reduced to a minimum. The interior construction of the building is such that the working area can be kept scrupulously clean.

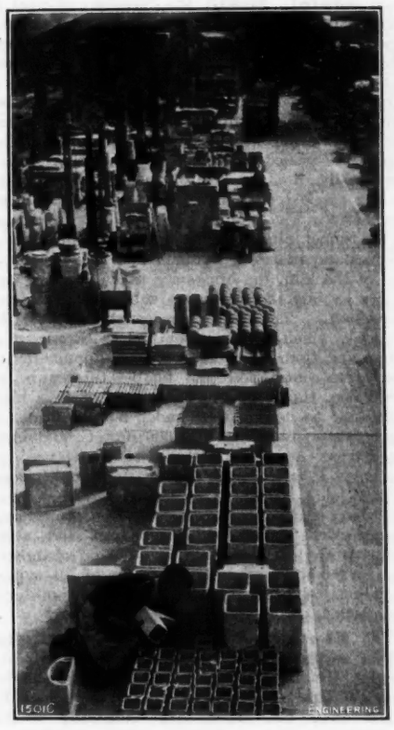


FIG. 3. SHOP FOR SPECIAL REFRACTORIES.

The raw materials utilised come from Dorset, Cornwall, Scotland and other parts of the United Kingdom, and from France, India, South Africa and other overseas countries. They enter the works, for the most part, by rail. Before they are put into storage bins, samples are taken and tested in the works process-control laboratories. After acceptance, the wagons are taken to the sidings, which are about 15 ft. above the works datum, and are there unloaded into chutes leading to bins which are level with the works roadway and adjacent to the milling and grinding plant supplying the production departments. Many of the raw materials have to be calcined before use and this is done in an oil-fired rotary kiln 110 ft. in length and 6 ft. in diameter. The grinding, milling and blending department is equipped with roll and cone crushers and pulverisers. After screening, the materials are conveyed to elevators which discharge them into storage hoppers. The plant is designed for completely automatic operation and, by means of a control panel which is in process of being installed, any pre-determined flow sequence may be set up, thus reducing to a minimum the possibility of error.

After grinding and grading, the material for MR1 refractory bricks (the type now in production) is automatically weighed and blended. Each ingredi-

ent is repeatedly passed over powerful electro-magnets until all particles of iron which might have been picked up during the grinding operation have been removed. Finally, the blended material is conveyed to stainless-steel lined storage bins in the brick-making shop. Here, it passes into mixers which, like all the other plant employed, are lined with stainless steel. Water is added to produce a mixture of the correct consistency and, after subjection to a pressure of about 1 ton per square inch in a mechanically-operated brick press, the bricks are passed through a continuous drier and are finally fired in an oil-heated tunnel kiln. Bricks stacked on cars ready to enter the drier are shown in Fig. 2, on page 757. The temperature of the tunnel kiln is controlled by means of thermo-couples and radiation pyrometers. From the exit end of the kiln, the bricks are taken to store and before leaving the works are subjected to a final inspection. The main characteristic of the MR1 firebrick, which contains from 52 to 53 per cent. silica, and from 43 to 44 per cent. alumina, is its low after-contraction at temperatures up to 1,600 deg. C. It is also claimed to possess high resistance to deformation under normal loads at temperatures in excess of 1,600 deg. C. and high mechanical strength with good resistance to spalling. It is recommended for such applications as the side walls of reheating, reverberatory, and billet-heating furnaces, for regenerators and chequerwork chambers in the iron and steel industry and for lining the combustion chambers and target walls of boiler furnaces of all types, including solid-fuel, pulverised-fuel or oil-fired installations.

The MI range of low heat-storage insulating bricks is produced in a separate building. At present, the plant is working on MI28 bricks for use at face temperatures of 2,800 deg. F. (1,538 deg. C.). These are essentially kaolin bricks having a very open structure obtained by mixing graded softwood flour with the clay and afterwards burning out the combustible matter. After being pressed into shape, the bricks are passed through a continuous drier and are finally subjected to very high temperatures in an oil-fired tunnel kiln. After cooling, the bricks are ground on all six faces to accurate dimensions. This ensures tight, thin joints and reduces the labour required in furnace construction. After grinding, each brick is inspected individually and the strength automatically tested. The bricks are then packed by hand in cartons and sent to storage. The MI bricks are light in weight and, considering their structure, very strong. In addition, they have a very low thermal conductivity, and their heat capacity and storage are also extremely low.

In the section of the works in which "Battersea" refractories, as they are termed, are made, weighed materials received from the grinding and milling plant are fed into mixers, water is added and the batch prepared to a suitable consistency according to the range of articles it is intended to produce. The mixed material is dropped into specially designed aluminium containers held in storage racks which are delivered direct by a fork-lift truck to the individual maker, who may be a hand moulder, a machine moulder or engaged in machine pressing or in extrusion and slip casting work. As stated above, furnace tubes, crucibles, muffles, cupels and other special refractory vessels and shapes are produced in this shop, a view of the floor of which is shown in Fig. 3, on page 757. The empty aluminium containers are subsequently returned to the mixing section and thoroughly cleaned in order to avoid contamination of subsequent batches. After drying, the moulded, pressed or extruded refractories are fired in one of a variety of kilns according to the product. They range from simple coke-fired or oil-fired beehive kilns to a specially designed gas-fired tunnel kiln, and include specially constructed furnaces capable of giving the extremely high temperatures required for grades of refractories such as fused and recrystallised alumina. The section of the works in which the fourth group of materials is made, namely, refractory concretes and cements, mouldable refractories and insulating concretes, is housed in two buildings on the new site.

THE BRITISH ELECTRICAL POWER CONVENTION.

THE fifth British Electrical Power Convention opened at Torquay on Monday, June 8, and ends to-day, Friday, June 12. The president is Sir John Hacking, and some 35 organisations, which are constituent members of the Convention, were represented, the attendance numbering about 2,100. The proceedings began on Monday evening with the official opening of an electrical exhibition at the Torwood Garage by the President. The equipment shown at this exhibition, which was organised by the British Electrical Development Association, was largely of a domestic and agricultural character. Examples of some of the more moderate sized switchgear were, however, on view and these we propose to describe at a later date. In the field of electronics Messrs. Ferranti, Limited, Hollinwood, were showing a high-speed tape reader, which was originally designed for use with high-speed digital computers. With this apparatus it is possible to read five-hole or seven-hole teleprinter tape at the rate of 200 characters per second, if run continuously. The reading is done photoelectrically.

PRESIDENTIAL ADDRESS.

The first formal meeting was held at the Pavilion on Tuesday morning, June 9, when a civic welcome was accorded to the delegates by the Mayor of Torquay. The President then delivered his address, in which he said that the topic of the Convention was "Electricity and National Prosperity." It would be a suitable prologue to the discussions that were to take place for him to consider the broader aspects of the energy problem, of which the supply of electricity was but a part. Nations, as well as individuals, were notorious for their prodigality in disposing of readily available resources. Between 1814 and 1913 our direct exports of coal and coke had reached 1,700 million tons, mainly of the higher grades and sufficient, had it been retained, to provide 40 per cent. of our annual requirements on the present scale for a period of 20 years. There was, of course, no reason why this coal should not have been exported. In fact, it was upon that trade that our industrial supremacy was built up. Our lavishness in providing for the energy requirements of other countries was matched by an equal prodigality in home use. Even in the latter part of the period under consideration, in spite of the emergence of the steam turbine and the electric motor, there was very little improvement in the efficiency with which the nation was using fuel.

It was not until the 1914-18 war that the overall fuel situation began to show significant improvement. After that war, although we continued to export coal on a large scale, our imports of oil and petrol formed a substantial supplement to the energy available, being equivalent between 1920 and 1939 to some 200 million tons of coal. By 1951, although the total population had increased by 13 per cent. and the national income by more than 75 per cent., the total consumption of coal, oil and petrol had increased by only 33 per cent. It seemed likely, too, that the comparative national output per head of population in 1951 was nearly double that of 1920-25 for an increase of less than 20 per cent. in fuel expenditure, in spite of the adverse factors now affecting fuel economy. This improvement in fuel utilisation was partly due to the striking improvements in the luminous efficiency of electric lamps and the substitution of gas by electric lighting. It was also partly due to the improvements in the production of mechanical power by the replacement of inefficient plant which electrification made possible.

For lighting and mechanical power the pattern of development was therefore clear. It was only when we came to heating that we found solid fuels, gas and electricity in competition, so that it was impossible to dictate in general terms the best fuels for a particular purpose. This competition arose from the form of our main source of energy—coal—and would disappear if coal were to be replaced by an abundant new source of energy, such as nuclear fission. The best prospect of achieving appreciable fuel economy in the domestic heating field was to pay more attention to the reduction of the heat losses from buildings by adopting proper standards of insulation. In this way it should be possible to halve the coal required for domestic space-heating. As with all schemes for fuel saving this would, however, involve considerable capital expenditure. To achieve measurable total savings within a reasonably short time it was therefore more important to devote attention to existing buildings. Heating in all its forms accounted for from 30 to 35 per cent. of the public consumption of electricity, and of this amount an appreciable proportion was for industrial applications. Acceleration or retardation of domestic electric heating in the near future was therefore unlikely greatly to affect the growth of total demand. Failure to obtain an increasing share of this load, however, would lead—unless compensated by increased shift working in industry—to a lower system load factor and consequently to higher charges to all classes of consumers.

It could be concluded that almost the whole of the improvement in the national efficiency of fuel utilisation since 1925 was attributable to industry, and that one of the major causes of this improvement was the large-scale substitution of publicly-generated electric power for less efficient production—either mechanical or electrical—by industry itself. The consistent improvement in efficiency achieved by the electricity supply industry must also be taken into account. In 1924 over half the electrical energy absorbed by industry was supplied by private plant, but in 1950, when the total requirements had increased four times, the proportion obtained from private plant had fallen to one quarter. Moreover, between 1920 and 1952, metallurgical-coke ovens had effected a reduction of 17 per cent. in fuel consumption per unit of output, while the corresponding figures for the steel industry, the gas industry and the electricity supply industry were 45 per cent., 12 per cent., and 56 per cent., respectively. Taken together, these four industries accounted for almost half our present coal consumption, and it might be assumed that further improvements in their efficiency would be obtained.

As regards future fuel requirements, the Ridley Committee had expressed the view that by 1961 the annual inland demand for coal might be some 230 million tons, on the assumption that industrial production would increase by 4 per cent. and fuel efficiency by 1 per cent. There was, however, little doubt that an average annual improvement in industrial production of 4 per cent. was inadequate if we were to regain our position in the world's markets. It would therefore seem reasonable to assume an average increase in fuel requirements of two million tons a year, which would mean a total annual requirement of about 300 million tons in 50 years time. There could, however, only be few who would hold out the slightest prospect of ever approaching an annual production of 300 million tons; and the question therefore was how the gap was to be bridged. One possibility was the underground gasification of thin coal seams, but present indications did not suggest that this was likely to reach significant proportions. Nor did it seem likely that any appreciable part of the deficit could be made up by additional imports of oil. Clearly, therefore, we must develop as a matter of urgency such alternative sources of energy as seemed likely to prove economic. All these, however, entailed relatively heavy capital investment. Moreover, the greatest savings that we could possibly hope to achieve from such sources as water, wind and tidal power in 20 years time would be some five million tons of coal per annum.

There remained the nuclear sources of energy. A nuclear power station to consume natural uranium was to be built in Cumberland, some information about which had been given by Sir John Cockcroft last January (see page 84 *ante*). He had indicated that the capital cost of such a station was unlikely to exceed twice that of a conventional steam station and that the fuel cost would probably be less. Reliable comparisons would, of course, only be possible after practical working experience. Nevertheless, it was clear that a stage had been reached when the building of one, or preferably more, large-scale experimental plants was justified; and he (Sir John Hacking) fully expected

that we should go ahead with plans to consume natural uranium on a scale which would make a significant contribution to supplies of electrical energy 15 to 20 years hence. Owing, however, to the extremely small proportion of nuclear fuel contained in natural uranium, the long-term solution of our energy problem would depend on the development of the breeder reactors and there seemed little doubt that in terms of the next one hundred to two hundred years nuclear fission would provide us with an abundant new source of energy, which would be delivered in the form of electricity.

In the meantime, we were faced with an urgent two-fold task: to find ways of eking out our present resources so as to provide the ever-increasing quantities of energy demanded by the march of civilisation and to press ahead our nuclear development with all possible speed. In both these directions success was likely to depend to a large extent on the amount of capital that was available. At present we were at a stage when important changes might occur in the basic factors to be taken into account. We were confronted with three major uncertainties. One of these was how to maintain competition in the export markets, and an important contribution towards this would be a general change from one to two-shift working. Another was how the development of the gas industry would be affected by the rising price of coal, the shortage of coal suitable for carbonisation, and the possible total gasification of lower-grade coals. The third was the rate at which nuclear power stations would be built. The next 10 to 15 years would see supplies of electricity brought within the range of all but a fractional minority of the premises in Great Britain. Of the three main fuels it was the only one able to supply certain household services, and it could satisfactorily supply all the others. The triplication of capital and operating costs involved in distributing three forms of energy to the domestic consumer might therefore be found to be an unnecessary expense far outweighing any savings which might accrue from marginal differences in the efficiencies of production and utilisation. There was a clear trend towards reduction in the direct use of raw coal by the ultimate consumer and its substitution by one of the secondary fuels. Could it be that a stage would be reached when the cost of maintenance and replacement of some of the older gas-distribution systems became too heavy, so that outlying residential districts were abandoned and supply concentrated in industrial areas for processes where it had special advantages? Or would the search which was to be made for natural gas reserves in this country meet with such success that continued expansion of gas supply became not only feasible but nationally desirable?

The second meeting of the Convention was held on Tuesday afternoon, June 9, when a paper entitled "Electricity and National Prosperity" was presented by Colonel B. H. Leeson. An abridgement of this contribution, which was subsequently discussed, appears on page 766 of this issue.

In the evening, a joint reception was held at the Town Hall by the Mayor and Mayoress of Torquay and the President and Lady Hacking.

(To be continued.)

THE IRON AND STEEL INSTITUTE: ERRATUM.—Our attention has been drawn to a small typographical error which has occurred in our report, on page 617, *ante*, of the discussion on "Railway Traffic in Steelworks," held on April 30 during the annual general meeting of the Iron and Steel Institute. The figure given by Mr. W. McLester for the recent increase in blast-furnace output should read "approximately 30 per cent." and not 50 per cent., as recorded.

MERCURY SWITCH RELAY.—A relay recently placed on the market by Londex, Ltd., 207, Anerley-road, London, S.E.20, has been designed to operate on direct-current circuits containing heavy-duty contacts. The mercury switches used have maximum current ratings of 6, 10 or 20 amperes, the 6-ampere switches being rated at 250 volts alternating current, while the others, which have porcelain anti-tracking linings, are suitable for use on direct-current and up to 500 volts alternating. The power required for operation varies from 0·25 to 1 watt, depending on the number and size of the switches. As, however, the coils are continuously rated at 3 to 4 watts, considerable overloads can be carried.

THE HONOURS LIST.

MANY engineers, industrialists and scientists are among those whose names are contained in the combined Coronation and Birthday Honours List. The principal names are given below.

BARONETS.

Mr. Alfred C. Bossom, J.P., Member of Parliament for Maidstone; and Sir Percy H. Mills, K.B.E.

KNIGHTS BACHELOR.

Dr. Edward C. Bullard, director, National Physical Laboratory; Mr. Sydney Camm, C.B.E., director and chief designer, Hawker Aircraft, Ltd.; Mr. Walter J. Drummond, deputy chairman, National Coal Board; Mr. Ernest W. L. Field, C.B.E., director, Scottish Engineering Employers' Association; The Hon. Francis J. Hopwood, managing director, Shell Transport and Trading Co., Ltd.; Mr. Andrew Naesmith, C.B.E., J.P., general secretary, Amalgamated Weavers' Association and member of the Iron and Steel Board; Mr. Stanley W. Rawson, director-general of machine tools, Ministry of Supply; Mr. Harold C. W. Roberts, C.B.E., M.C., chief inspector of mines and quarries, Ministry of Fuel and Power; Mr. William R. V. Smith, J.P., chairman, Bristol Local Employment Committee; and Mr. Thomas O. M. Sopwith, C.B.E.

ORDER OF THE BATH.

G.C.B.—General Sir Ouvry L. Roberts, K.C.B., K.B.E., D.S.O., A.D.C., Colonel Commandant, Corps of Royal Engineers.

K.C.B.—Sir John D. Cockcroft, C.B.E., chairman, Defence Research Policy Committee, scientific adviser to the Minister of Defence, and director, Atomic Energy Research Establishment.

C.B.—Mr. R. Cockburn, O.B.E., scientific adviser to the Air Ministry; Rear Admiral (E) A. D. McGlashan, D.S.O.; Mr. E. T. Jones, O.B.E., principal director of scientific research (air), Ministry of Supply; Mr. E. B. Hugh-Jones, M.C., chief engineer, Highways Engineering Staff, Ministry of Transport; and Mr. J. A. R. Pimlott, Under-Secretary, Ministry of Materials.

COMPANION OF HONOUR.

The Rt. Hon. Thomas Johnston, P.C., LL.D., chairman, North of Scotland Hydro-Electric Board.

ORDER OF SAINT MICHAEL AND SAINT GEORGE.

C.M.G.—Mr. R. E. Hardingham, O.B.E., secretary and chief executive, Air Registration Board.

ROYAL VICTORIAN ORDER.

C.V.O.—Lieutenant-Colonel F. C. C. Balfour, C.I.E., C.B.E., M.C.

M.V.O. (*Fourth Class*).—Major J. R. Maudslay, M.B.E. [a great-great-grandson of Henry Maudslay (1771-1831)].

IMPERIAL SERVICE ORDER.

Mr. J. H. Jones, chief engineer, Ministry of Finance, Northern Ireland.

ORDER OF THE BRITISH EMPIRE.

K.B.E.—Mr. John A. Carroll, deputy controller (research and development), Admiralty; Sir Greville S. Maginness, chairman, Churchill Machine Tool Co., Ltd.; Sir Charles J. Mole, M.V.O., O.B.E., Director-General of Works, Ministry of Works; and Sir Frederick E. Rebbeck, J.P., D.L., chairman and managing director, Harland and Wolff, Ltd., Belfast.

C.B.E.—Mr. A. Agar, chairman and managing director, Davidson & Co., Ltd.; Mr. R. G. Baker, deputy chairman, North Eastern Division, National Coal Board; Mr. Edmund Bruce Ball, managing director, Glenfield and Kennedy, Ltd.; Mr. F. S. Barton, principal director of electronic research and development, Ministry of Supply; Mr. J. N. Brown, assistant comptroller, Patent Office and Industrial Property Department, Board of Trade; Mr. R. W. Cheshire, deputy chief scientific officer, Admiralty; Rear Admiral (E) R. Cobb, O.B.E.; Mr. D. D. W. Cole, assistant controller (production), Atomic Energy Establishment, Risley, Ministry of Supply; Mr. B. E. Common, chairman, Tyne Improvement Commission and director, Common Brothers, Ltd.; Mr. R. G. Cooke, director, Society of Motor Manufacturers and Traders, Ltd.; Mr. J. Donovan, member, Docks and Inland Waterways Executive; Professor W. J. Duncan, Mechan Professor of Aeronautics and Fluid Mechanics, University of Glasgow; Mr. A. Fage, Superintendent, Aerodynamics Division, National Physical Laboratory; Mr. N. A. Gass, M.C., a managing director, Anglo-Iranian Oil Co., Ltd.; Mr. J. E. Hurst, J.P., President, British Cast Iron Research Association; Mr. E. A. G. Johnson, chief engineer, Ministry of Agriculture and Fisheries; Mr. T. Lawrie, general manager, North of Scotland Hydro-Electric Board; Mr. R. H. M. Lea, general manager of the Electricity Trust, State of South Australia; Mr. L. le Couteur, deputy chief inspector of factories, Ministry of Labour and National Service; Colonel B. H. Leeson, O.B.E., T.D., director, British Electrical and Allied Manufacturers Association; Mr. R. G. Lloyd, secretary, Royal Commission on Awards to Inventors; Mr. F. C. McLean, M.B.E., deputy chief engineer, British Broadcasting Corporation; Mr. K. C. Mann, director of works (overseas), Air Ministry; Mr. A. McL. Mooney, deputy director of electrical engineering, Admiralty; Mr. C. W. Moss, director, Vickers-Armstrongs Ltd.; Mr. H. Nimmo, chairman, Southern Electricity Board; Mr. D. A. Oliver, metals economy adviser, Ministry of Supply; Captain (E) P. D. Oliver, R.N.(ret.); Mr. J. Rawlinson, chief engineer, London County Council; Mr. D. N. Rayner, director of contracts, Ministry of Supply; Colonel G. E. Rhodes, senior engineering inspector, Ministry of Housing and Local Government; Mr. H. E. Sheardown, chairman of directors, Cook, Welton and Gemmell, Ltd.; Mr. R. B. Southall, director and general manager, National Oil Refineries, Ltd.; Mr. J. Summers, O.B.E., chief test pilot, Vickers-Armstrongs Ltd.; Mr. M. C. Tozer, assistant secretary, Ministry of Fuel and Power; Mr. M. Milne-Watson, chairman, North Thames Gas Board; Lieutenant-Colonel G. R. S. Wilson, R.E.(ret.), chief inspecting officer of railways, Ministry of Transport; and Mr. H. S. Young, T.D., deputy chief scientific officer, Ministry of Defence.

O.B.E.—Mr. F. W. Abraham, motive power superintendent, London Midland Region, British Railways; Captain M. J. R. Alderson, fleet manager, Comets, British Overseas Airways Corporation; Mr. G. R. Armstrong, chief engineer, m.s. Esso Bedford, Esso Transportation Co., Ltd.; Mr. J. G. Ballingall, principal scientific officer, Torpedo Experimental Establishment, Greenock; Wing Commander R. P. Beamont, D.S.O., D.F.C., chief test pilot, English Electric Co., Ltd.; Mr. A. C. Best, principal scientific officer, Meteorological Office, Air Ministry; Mr. A. J. Bowron, managing director, F.N.F., Ltd., textile engineers, Burton-on-Trent; Mr. W. Buckie, technical manager, Swan, Hunter, and Wigham Richardson, Ltd.; Mr. J. G. Bullen, general manager, Highland Reduction Works, British Aluminium Co., Ltd.; Mr. C. F. Burden, deputy director, Aeronautical Inspection Services, Air Ministry; Mr. C. Chambers, chief engineer, Fighter Command, Royal Air Force; Commander (L) A. E. Chiverton, R.N.; Commander (E) P. L. Cloete, R.N.; Mr. A. L. Cochrane, chairman and managing director, Cochrane and Sons, Ltd., Selby, Yorkshire; Mr. L. C. Coombes, M.B.E., constructor, H.M. Dockyard, Chatham; Mr. R. Cousland, shipbuilding manager, J. Samuel White & Co., Ltd., Cowes; Mr. H. J. Curnow, assistant director, Aircraft Production Supplies (Materials), Ministry of Supply; Mr. J. E. Davis, chief technical officer, South Eastern Gas Board; Mr. R. V. Eaton, superintendent, Royal Naval Propellant Factory, Caerwent, Monmouthshire; Mr. A. Falzon, manager, Water and Electricity Department, Malta; Mr. P. H. Ford, formerly works manager, Guest, Keen and Nettlefolds, Ltd., Birmingham; Mr. F. A. Gear, assistant director, technical and personnel administration, Ministry of Supply; Mr. C. W. Scott-Giles, secretary, Institution of Municipal Engineers; Mr. J. T. Graham, M.I.Mech.E., of Worthington-Simpson, Ltd., employer vice-chairman, North Midland Regional Board for Industry; Mr. H. C. Grimshaw, principal scientific officer, Safety in Mines Research

Establishment, Ministry of Fuel and Power; Mr. W. H. Grinsted, M.B.E., chief engineer, Siemens Brothers & Co., Ltd., Woolwich; Commander (E) J. N. F. Haigh, R.N.(ret.); Commander (E) T. S. Hayes, D.S.C., R.N.(ret.); Mr. J. G. Heaslip senior engineer, South Eastern Divisional Road Engineer's Office, Ministry of Transport; Mr. G. H. A. Hughes, director, London Master Builders' Association; Mr. W. H. M. Jackson, employers' secretary, National Joint Industrial Council for the Electric Cable-Making Industry; Mr. E. Jones, senior executive engineer, Colonial Engineering Service, Nigeria; Mr. A. Logan, technical manager, Marine Administration, Anglo-Saxon Petroleum Co., Ltd.; Mr. G. C. Lowry, T.D., clerk to the governors, Imperial College of Science and Technology, University of London; Mr. J. M. Morris, M.B.E., chief electrical and mechanical engineer, Basra Port; Mr. J. C. Needham, chairman, Evershed and Vignoles, Ltd.; Mr. A. E. Nelson, chief engineer, s.s. Kenya, British India Steam Navigation Co., Ltd.; Mr. D. M. O'Neale, deputy director of works and hydraulics, Colonial Engineering Service, Trinidad; Mr. R. W. Parsons, principal, School of Mines and Industries, State of South Australia; Mr. E. L. E. Pawley, head of engineering services group, British Broadcasting Corporation; Mr. W. R. Piggott, principal scientific officer, Radio Research Station, Department of Scientific and Industrial Research; Mr. N. Sizer, M.B.E., M.C., assistant chief engineer, Ministry of Works; Mr. E. L. Snell, chief engineer, Essex River Board; Mr. C. M. Spielman, M.C., managing director, Whessoe, Ltd., Darlington; Mr. W. C. Swift, assistant director, engineering, Ministry of Supply; Mr. F. H. Tomes, chief engineer, Lincolnshire River Board; Professor C. J. Tranter, Associate Professor of Mathematics, Royal Military College of Science, War Office; Mr. H. J. H. Wassell, chief radar development engineer, Marconi's Wireless Telegraph Co., Ltd.; and Mr. C. T. Wilkins, assistant chief designer, de Havilland Aircraft Co., Ltd.

M.B.E.—Mr. W. G. Allen, senior experimental officer, Directorate of Electronics Research and Development (Air), Ministry of Supply; Mr. A. Anslow, production manager, Joseph Sankey and Sons, Ltd., Wellington, Shropshire; Mr. E. W. Ashby, chief tanker designer, Joseph L. Thompson and Sons, Ltd., Sunderland; Mr. E. B. Babler, chief, Metallurgic and General Research Laboratory, Allen West & Co., Ltd., Brighton; Mr. A. Baxter, assistant manager, Shipbuilding Department, Vickers-Armstrongs Ltd., Barrow-in-Furness; Mr. A. H. Blackwell, director and works manager, David Brown Companies, Meltham, Yorkshire; Mr. J. Bryce, manager, Shipyard Plant Department, Harland and Wolff, Ltd., Belfast; Mr. J. Buckley, works manager, Thomas Robinson and Son, Ltd., Rochdale; Mr. A. H. Carding, works director, Smart and Brown (Machine Tools), Ltd., Biggleswade; Mr. S. C. H. Fossett, works manager, Carriage and Wagon Works, North Eastern Region, British Railways; Mr. V. Gray, naval architect, Cochrane and Sons, Ltd.; Mr. R. J. R. Hancock, senior structural engineer, Ministry of Works; Mr. W. J. Hobbs, works manager, Drayton Regulator and Instrument Co., Ltd., West Drayton; Mr. W. W. Hopkinson, station engineer, Dartford and Belvedere, South Eastern Gas Board; Mr. A. S. Keeling, Midland district engineer, South Western Division, Docks and Inland Waterways Executive; Mr. G. King, senior research chemist, Albright and Wilson, Ltd.; Mr. A. H. Laidlaw, chief draughtsman, Vosper, Ltd., Portsmouth; Mr. R. H. Linnell, factory superintendent, British Thomson-Houston Co., Ltd., Leicester; Mr. A. V. Lovelock, development and production manager, S. G. Brown, Ltd., Watford; Mr. J. MacGregor, works manager, Thermotank, Ltd., Glasgow; Mr. J. H. Naylor, district commercial engineer, Yorkshire Electricity Board; Mr. G. A. H. E. Poole, factory manager, Joseph Lucas, Ltd., Birmingham; Mr. G. T. Richards, senior research assistant, Science Museum; Mr. H. N. Scott, manager, outside engineering department, Harland and Wolff, Ltd., Glasgow; Mr. T. A. Smith, chief engineer, Alley and MacLellan, Ltd., Glasgow; and Mr. F. G. V. Vincent, plant engineer, Supermarine Works, Vickers-Armstrongs Ltd., Swindon.

LABOUR NOTES.

INCREASES in miners' wages were forecast by Mr. Abe Moffat, President of the Scottish area of the National Union of Mineworkers, at the annual conference of the area, which opened at Aberdeen on June 3. In his address to the delegates, Mr. Moffat laid special emphasis on the need for a new wage structure for the coal-mining industry and criticised the Government's policy of restricting claims for increased wages by miners and other classes of workpeople. He said that several unions had formulated their policies for securing wage advances already, and expressed the view that miners and "millions of other trade unionists" would demand increases during the present year. Trade unionists could not allow themselves to be deceived into believing that employees must accept low wages in order to save the country, when they knew that never before had profits been so high or had so much been spent on rearmament.

As to the high price of coal; the Government was responsible. The ordinary consumer paid 6*l.* a ton for his coal, but it was the average selling price at the pithead, 3*l.* a ton, that determined the miner's wages and the profit and loss result of the mining industry. Mr. Moffat objected to the high rate of compensation paid to the former mine owners and said that nearly 100 million pounds had been paid to them since the nationalisation of the mines in June, 1946. If this burden could be removed, coal at cheaper rates could be provided for ordinary consumers.

On the subject of wages, the delegates approved unanimously a resolution calling upon the union's national executive council to press determinedly for an increase for all day-wage earners, to enable them to meet the rising cost of living and to improve still further their living standards. There was some criticism that the amount of the increase was not stated. The trend of thought appeared to lean towards demanding plenty, judging by the phrases used by the delegates. One man suggested asking for 25*s.* a week more, but another delegate commented that an increase of a pound a day was not enough for the blood used in getting coal.

When moving the adoption of the resolution requesting more pay, Mr. Moffat claimed that the miners' demands could be met without coal costing domestic consumers a single penny extra. It could be accomplished, he affirmed, if the "financial manipulation" by which the mining industry bore the burden of selling coal at a loss to industrial consumers were stopped, and if the compensation being paid to the former owners ceased. Other steps required would be the cancellation of the profits tax on the industry, and the cessation of coal imports from the United States and elsewhere. He considered that there was no justification for compelling the mining industry to pay 5*l.* 3*s.* a ton for coal imported from overseas.

Mr. Moffat told the delegates that, since 1947, the wages of surface and underground miners had risen by 27 per cent., compared with an average of 35 per cent. for other classes of industrial employees. During the same period, the cost of living had increased by 39 per cent. Another resolution approved unanimously urged the union to pursue with the utmost vigour the question of introducing a new wage structure in the industry, not as a substitute for an increase in wages, but as an essential reform.

Other resolutions passed at the three-day conference included one urging the establishment of research and treatment centres to combat the rising incidence of pneumoconiosis and silicosis among Scottish miners. The delegates condemned the inadequacy of treatment centres, and the lack of doctors with special knowledge of these diseases, in Scotland. The use of machinery without dust suppressors in some pits was also criticised. It was stated that, although in the past, it had been thought that only South Wales mines were affected by these scourges, experience had shown that Scottish collieries were heavily involved. Delegates stated that only in South Wales was the position worse than in Scotland. The conference's proposals in this connection will be presented through the union's headquarters to the National Coal Board.

A special productivity number of *Asset*, the official journal of the Association of Supervisory Staffs, Executives and Technicians, has been issued. The journal advocates the encouragement of a production-conscious attitude by both sides of industry. It states that there is a good deal of loose thinking on this question, from which neither side of industry is immune. The function of the trade unions is not to quarrel about the hypothetical rewards from production not yet attained, but rather to show that higher productivity can be achieved, and to accomplish that with a minimum of delay. The journal urges that, at the same time, it should not be the purpose of any management to speed up processes with the intention of rendering workpeople redundant. Either attitude of mind can mean disaster to efforts for increased production and without such an increase Britain will meet with disaster.

The standard of living of all in Britain depends upon the productive efficiency of the nation's industry and services, the journal reminds its readers. Half of the country's total food and most of its raw materials are imported in exchange for exports of manufactured goods. These goods can only be sold in a progressive and competitive world if the real costs of production in Britain make British prices competitive. Three proposals for furthering increased productivity were put forward recently at a conference sponsored by the British Productivity Council and attended by representatives of the Association. One was for a circuit scheme among groups of factories in a given locality for the interchange of visits from teams representing the other factories in the group, with the object of pooling ideas and knowledge. The others suggested the setting up of committees in some 150 towns to foster productivity, and the exhibition of films advocating improved methods of manufacture.

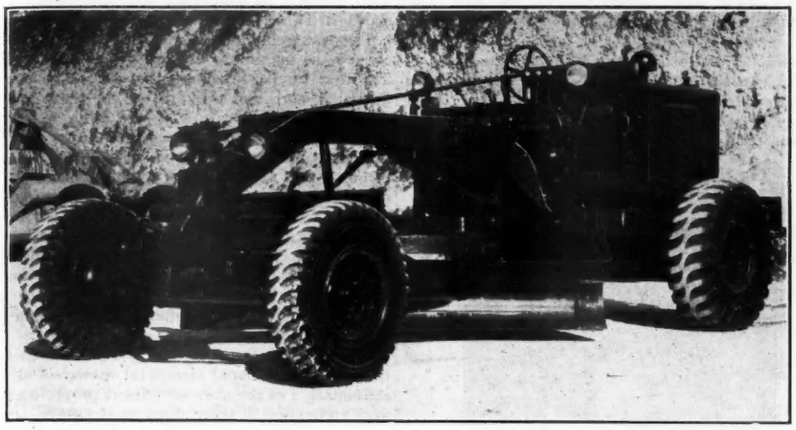
The annual conference of the Association of Supervisory Staffs, Executives and Technicians opened at Clacton on June 6. It is understood that a report was made to the delegates on the progress of the discussions between the union's executive committee and the Ministry of Labour and National Service, on the difficulties which have arisen regarding the dispute on foremen's wage claims being submitted to arbitration by the Industrial Disputes Tribunal. At the session on Sunday last, delegates passed a resolution requesting the resignations of members of the T.U.C. General Council who have agreed to serve on the Iron and Steel Board.

On this question, Mr. Andrew Naesmith, C.B.E., who accepted a part-time appointment to the Iron and Steel Board, made a personal statement to the central committee of the Amalgamated Weavers' Union, of which body he is general secretary. He stated subsequently that the committee regarded the matter as purely personal to himself, and had neither applauded nor condemned his action in accepting the post. Mr. Naesmith will retire from the secretaryship of the A.W.U. at the end of July, on reaching the age limit. He said that the offer of a knighthood had been made weeks before he was known to be retiring and still more weeks before he was invited to join the Board.

Civil Service pay claims came up for further discussion with Treasury officials on June 4, when representatives of the First Division Association submitted fresh evidence in support of its claim that the salaries of its members should be increased to such an extent as would restore their relationship with the salaries of other professional employees to its pre-war level. The Association is the staff body which represents the highest administrative grades of the Civil Service and it caters for all ranks from assistant principal to permanent secretary. Another meeting will be held shortly.

MOTOR GRADER AND SCARIFIER.

BLAW KNOX, LTD., LONDON.



MOTOR GRADER AND SCARIFIER.

THE new BK-10 motor grader shown in the accompanying illustration is now in production at the works of Blaw Knox, Limited, Rochester, Kent. It is powered by a Leyland type AU350-5 six-cylinder four-stroke cycle Diesel engine developing 70 brake horse-power at 1,650 r.p.m. The blade of the grader is 10 ft. across, and all its movements are power operated. The controls are conveniently grouped in an open-type cab, arranged to accommodate two persons, but a closed all-weather cab or tropical canopy, which can be easily fitted, is also made. The scarifier, which is extra equipment, is of the V-type of construction and has nine tines and a cutting-width of 42 in.; the effective weight on the tines is 7,206 lb. It enables hard and compact surfaces such as tar macadam, sun-baked tropical terrain and oil-bound surfaces to be effectively broken up. The pitch of the scarifier teeth and position of the teeth in the tooth bar have been made adjustable.

The grader is built round a one-piece main frame type of chassis in the form of a letter "Y," the tail of which carries the front axle and steering links and the two arms carry the gearbox, the final drive, and the rear wheels. The engine is mounted directly above the rear axle, and the driving seat and controls are placed forward of the engine. The blade is suspended at the centre beneath the frame, and the frame itself is constructed from continuous rolled-steel sections, pressed in pairs, to ensure correct alignment, and electrically welded by a continuous automatic process. It is reinforced at the points of stress for rigidity, and a head casting is welded integrally with the main frame to provide stability at the front end. As can be seen in the illustration, an unobstructed view for the operator is provided by the layout adopted which also permits a wide range of blade movement.

The Leyland engine is fitted with a 16-in. diameter single dry-plate clutch. A six-speed gearbox gives a range of road and operating speeds from 2·31 m.p.h. in first gear up to 19·70 m.p.h. in top gear, and two reverse gears give speeds between 3·08 m.p.h. and 4·90 m.p.h. The transmission gears are made of alloy steel, and run in ball and roller bearings. The hand brake for parking locks on to the transmission and Lockheed hydraulic brakes are fitted on the two rear driving wheels. A solid type of final drive to the two rear wheels is provided, and the tyres fitted are 14·00 by 24 low-pressure earth-mover tyres. The final drive gears are wide faced and the shafts are mounted on taper-roller bearings of the heavy-duty type. It is claimed that the power controls are easy to operate and require little maintenance. From the engine crankshaft, power is transmitted through a worm reduction gear to a vertical drive shaft, thence through bevel gears to the power-control box. The controls are engaged by spring-loaded dog-clutches, the jaws of which have been generated to ensure ease of engagment and disengagement. From each control the power is transmitted through a tapered shaft and, in the case of the blade-lift controls, by bevel gears to the blade-lift gearbox mounted on the front of the cab. The power drive for the wheel lean, scarifier, circle and centre-shift movements is taken through square-section shafts and Hardy-Spicer universal joints. In the case of a heavy overload being applied, damage to the control mechanism is prevented by a shear pin which is fitted in the vertical drive shaft and is easily replaced; it is accessible through a small inspection cover in the cab. The blade-lift links are telescopic and are adjustable to five different lengths and permit a wide range of blade movements.

The steering gearbox is of the Marles double-roller type and has a box ratio of 28·5 to 1; it is designed for heavy-duty operation, such as is necessary when the machine is straight ditching, cutting or battering. The leaning front wheels are fitted as standard, and the power drive to them is taken from the control box Hardy-Spicer universal joints to a bevel gearbox and then to a second worm-driven gearbox which is mounted on the front axle beam; this worm and wheel provide the motion for leaning the front wheels to a maximum of 25 deg. either way. The blade-tilting frame is of welded box-section construction, spaced to give four-point support to the circle, and pivots on the main frame by means of a large-diameter ball and socket joint. Adjustable shoes on the tilting frame permit the circle to be easily reversed, and the blade is circled through a self-locking worm reduction gearbox which holds it positively in any desired position. The blade circle is made of cast steel and is machined to ensure a true diameter, to enable it to rotate freely in the supporting guides which can be adjusted both vertically and horizontally by removable shims. The teeth around the full circumference of the circle, permit movement of the blade through a full 360 deg., and the teeth are cut on the inside radius to protect them from damage and their large pitch, it is claimed, prevents dirt from packing into them.

The 10-ft. blade is secured to the circle by four quick-release pins. It is designed to give efficient "boiling" of the spoil and to roll it away cleanly into the windrows. The cutting edges and end bits are made of wear-resisting high-carbon steel and are replaceable, and wing extensions are made as extra equipment. All the normal blade working positions for right- or left-hand operation are obtainable from the driving position, through the power controls. The movement of the blade from a ditching to a bank-cutting position, for a flat-bottom ditch cut, a wide blade reach or to reverse the blade, is immediate without shifting from its normal centre mounting or adjustment of the telescopic links. The power controls are positive in operation and also permit the blade to be rigidly held in any position. The blade has a vertical adjustment of 90 deg., which permits it to be placed correctly for all kinds of work. When ditch cutting, either in a forward or reverse direction, the clearances allow unhindered blade movement with a free discharge of material, and 13 pitch positions are provided to assist in the setting of the blade to the correct angle for operation under all conditions. Large clearances at the front axle, scarifier and throat enable effective loading of the blade to be obtained and large windrows and deep cuts to be dealt with. The high lift of the blade and scarifier permit them both to be raised to avoid damage to shoulders when pulling out of cuts, and to clear obstructions such as high curbs, railway tracks, etc.

The 24-volt lighting is supplied as extra equipment and comprises two parking lights, stop and tail light, two headlights and one rear reversing light. Two floodlights can also be fitted to illuminate the blade for night operation. Many of the working parts of this grader have been made interchangeable with the larger BK-12 heavy-duty grader, to facilitate production and the stocking of spare parts. Its overall length is 21 ft. 5 in. and the overall width at the front is 8 ft. 1½ in., and 7 ft. 8½ in. at the rear. The height with a tropical canopy fitted is 10 ft. 4½ in. The wheelbase is 16 ft., the front wheel track is 7 ft. 1½ in., and the rear track is 6 ft. 6½ in.; this gives a minimum turning radius of 31 ft. 3 in. The clearance of the front axles is 15 in. and of the rear axle 14½ in.; the throat clearance, which is from the bottom of the circle to the cutting edge, is 23¼ in. The weight of the grader, complete with the scarifier, is 17,220 lb.

REPAIRS TO THE QUEEN'S STATE COACH.

AN interesting account of modifications carried out during the past year to the wheels of the Queen's State Coach is given in the May issue of *Aero Research Technical Notes*, published by the Technical Service Department, Aero Research, Limited, Duxford, Cambridge. The coach was built in 1761, and the wheels had become out-of-round through age, by nearly 1 in. at some points. The iron tyres were also not true. It was, moreover, desired to cover the noisy and uncomfortable iron tyres by rubber tyres. The alterations were entrusted to Hooper and Company (Coachbuilders), Limited, Western-avenue, London, and were done in consultation with Aero Research.

It was decided to carry out the repairs *in situ*, with the wheels mounted on their own axles, to ensure that they were trued up to conform with actual running conditions. The wheels were built up, after cleaning and degreasing, by painting on a layer of Araldite D and applying a cotton bandage material, thus forming a laminated plastic layer. After a sufficient thickness had been built up (requiring 80 lb. of resin and 1,500 yards of cotton), the plastic laminate was cured at a temperature of 50 deg. to 60 deg. C. by two infra-red element projective units. About half of the total thickness of plastic was then removed by a specially-designed steel cutter; the coach was supported by four jacks and the cutter was attached to a wooden block screwed to the floor under one of the wheels. After carefully centring the cutter, the wheel was rotated by hand and lowered on to the blade. The resin-impregnated material was thus trimmed to a truly circular face. False tyres, consisting of sections of 14-s.w.g. mild steel, to which were welded side ears or lugs, were then fitted to each wheel. After fitting, the steel bands were removed and had rubber strips Redux-bonded to them. The normal curing time of 20 minutes at 145 deg. C. was considerably extended to allow the heat to reach the adhesive layer through the thick metal pressure bars and clamps employed to secure a uniform pressure over the area of contact. All the assemblies were allowed to cool to room temperature before removing pressure. Finally, the rubber-steel sections were assembled on the built-up wheels by bolts screwed through the lugs and through holes tapped in the original iron tyres. Scarf jointing was used to join the tyre sections, using Araldite D up to within 1 in. of the outside surfaces; the Dunlop Rubber Company, Limited, who supplied the rubber tyre strips, then employed low-temperature vulcanising to complete the seal and provide a continuous rubber running surface.

ALUMINIUM AS A STRUCTURAL MATERIAL.

By M. BRIDGEWATER, B.Sc.

WITH its high strength, low weight and good corrosion resistance, aluminium is inherently an excellent structural material. By necessity, aeronautical engineers were the first to utilise its possibilities in this sphere, and, since their early use in the construction of airships, aluminium alloys have been employed on an increasing scale in aircraft structures. The aircraft industry has now built up a wide background of knowledge of the performance of aluminium and of the design principles necessary for its successful application to air-frames.

Despite this extensive technical background, it is only comparatively recently that engineers have begun to use this new material in the building and structural fields. This somewhat late beginning can be accounted for by the lack of circulation of aeronautical knowledge and by a relative scarcity of the material, which has only become plentiful since the rapid expansion of the producing industry during the recent war. Since then, however, structural engineers have shown an increased interest in aluminium, which has resulted in the design and erection of many fine light-alloy structures. Coinciding with this general awakening of interest has been the increased attention given to aluminium in the professional journals and technical Press. Many excellent general papers have been given, and the Institution of Structural Engineers has met the growing need for design information by the publication, in September, 1950, of its *Report on the Structural Use of Aluminium Alloys in Building*.

In a paper on "Aluminium in Structural Engineering," presented to the Aluminium Congress at Zürich in 1951, the late Colonel W. C. Devereux, who did so much to further the use of structural aluminium, estimated that, between the end of the war and May, 1951, 260,000 tons of aluminium had been used in the United Kingdom in the various building and structural spheres. The present extensive and world-wide expansion of the aluminium industry should ensure that there is sufficient metal to meet the increasing demand, and the increased output should help to reduce the cost of the virgin metal.

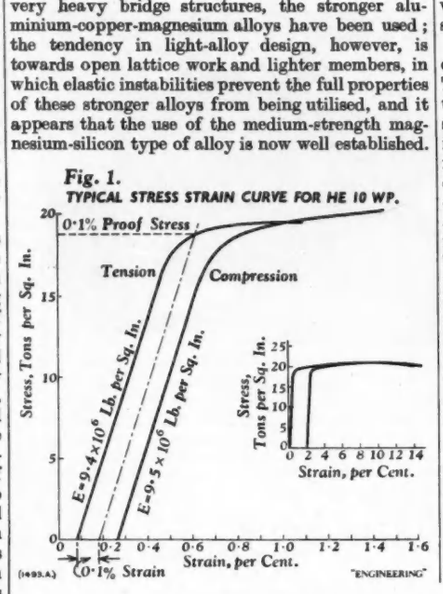
Considerable experience has now been gained in the use of aluminium in structural design, and ideas on the most suitable alloys and design principles have slowly crystallised. It is gratifying to find that there is a convergence of opinion among engineers engaged in this work, which promises well for the future. Over 90 per cent. of the general light-alloy structures at present being built or designed are in an alloy of the aluminium-magnesium-silicon type, as it has been found that the use of this alloy results in the most economical structure. Although lighter structures can be obtained by the use of the higher strength alloys, with ultimate tensile strengths up to 40 tons per square inch, their cost and comparatively low resistance to corrosion do not normally justify their use for anything other than aircraft structures.

It is the intention in the present article, therefore, to consider the magnesium-silicon alloy only and to try to show how its mechanical properties will affect the structural designer. The properties are very different from those of structural steel, and it is necessary, therefore, to treat aluminium on its own merits and not merely to consider it as a substitute for steel. This approach leads to many problems that are new to the structural engineer; the author, who has encountered most of these problems in the course of his work as development engineer with Northern Aluminium Company, Limited, here reviews the more important of them, and, where possible, suggests solutions.

PROPERTIES OF MAGNESIUM-SILICON ALUMINIUM ALLOY H 10.

Since the war, designers have experimented in all the available structural aluminium alloys and have determined independently that, for a majority of structures, the most economical design can be obtained with the aluminium-magnesium-silicon type of alloy. This is due to the fact that alloys of this type combine a strength approaching that of mild steel with a high resistance to corrosion and a moderate selling price—an important factor when dealing with an expensive material. For some of the very heavy bridge structures, the stronger aluminium-copper-magnesium alloys have been used; the tendency in light-alloy design, however, is towards open lattice work and lighter members, in which elastic instabilities prevent the full properties of these stronger alloys from being utilised, and it appears that the use of the medium-strength magnesium-silicon type of alloy is now well established.

Fig. 1.
TYPICAL STRESS STRAIN CURVE FOR HE 10 WP.



various names; these proprietary alloys, however, meet British Standard Specifications, which define limits in chemical composition and minimum mechanical properties. Details of these specifications, with mechanical properties and compositions, are shown in Table I.

The system of identification has been designed to convey the maximum information about the alloy. The first prefix, H, shows that the alloy is heat-treatable, and the letters after the alloy number show the precise nature of the heat treatment, i.e., W for the solution-treated condition and WP for the solution-treated and artificially-aged condition. The alloy number defines the chemical composition of the material, and the letter immediately in front of this number indicates the manufactured form, e.g., S for sheet and E for extrusion. Though the British Standard specified minimum properties should be used for design purposes, the proprietary alloys actually have properties that are well above these; typical values for extruded H 10 section are given in Table II, herewith. The properties are, for the most part, different from those of conventional structural materials and an examination of the more significant properties gives some indication of their effect on structural design.

Stress/Strain Curve.—Typical tension and compression stress/strain curves for HE10WP are shown in Fig. 1, herewith, from which it can be seen that there is a well-defined modulus, but that the departure from Hooke's Law is gradual and lacks the pronounced yield point of mild steel. In the absence of a well-defined yield point, and in view of the difficulty of measuring the limit of

TABLE I.—BRITISH STANDARD SPECIFICATIONS FOR MAGNESIUM-SILICON ALUMINIUM ALLOY.

Manufactured Form.	British Standard Specification.	Chemical Composition, Per cent.	Guaranteed Minimum Mechanical Properties.	W.	WP.
Extrusions ..	BS.1476 HE 10	Magnesium 0·4 to 1·5 Silicon 0·75 to 1·3	0·1 per cent. proof stress	7 tons per sq. in.	15 tons per sq. in.
			Ultimate tensile stress ..	12 tons per sq. in.	18 tons per sq. in.
			Elongation, per cent. ..	18	10
Sheet	BS.1470 HS 10	Magnesium 0·4 to 1·5 Silicon 0·75 to 1·3	0·1 per cent. proof stress..	7 tons per sq. in.	15 tons per sq. in.
			Ultimate tensile stress ..	12 tons per sq. in.	18 tons per sq. in.
			Elongation, per cent. ..	18	10
Plate	BS.1477 HP 10	Magnesium 0·4 to 1·5 Silicon 0·75 to 1·3	0·1 per cent. proof stress	7 tons per sq. in.	14 tons per sq. in.
			Ultimate tensile stress ..	13 tons per sq. in.	18 tons per sq. in.
			Elongation, per cent. ..	12	8
Forgings	BS.1472 HF 10	Magnesium 0·4 to 1·5 Silicon 0·75 to 1·3	0·1 per cent. proof stress	7 tons per sq. in.	15 tons per sq. in.
			Ultimate tensile stress ..	12 tons per sq. in.	18 tons per sq. in.
			Elongation, per cent. ..	18	10

TABLE II.—TYPICAL PROPERTIES OF A MAGNESIUM-SILICON ALUMINIUM ALLOY, NORAL 51S, CONFORMING TO HE 10 OF B.S.1476.

			W.	WP.
Composition	Si 1 per cent. Mg 0·6 per cent. Al remainder	0·1 per cent. proof stress (tons per sq. in.)	9	18
Modulus of elasticity ..	9·5 × 10⁶ lb. per sq. in.	Ultimate tensile stress (tons per sq. in.)	15	20
Density	0·098 lb. per cub. in.	Elongation, per cent.	20	13
Thermal expansion ..	24 × 10⁻⁶ per deg. C. (20 to 200 deg. C.)	Bearing yield stress (tons per sq. in) ..	15	20
Specific resistance ..	W, 3·9; WP, 3·6 microhms per cm. cube	Ultimate shear stress (tons per sq. in.) ..	10	14
		Fatigue strength (for 50 million cycles; tons per sq. in.)	6	6½
Thermal conductivity ..	0·44 C.G.S. units at 100 deg. C.	Brinell hardness	60	90
		Izod impact (ft.-lb.)	30	7

Alloy Specification.—In the "as cast" state, the magnesium-silicon alloy is a low-strength brittle material, and it has to be worked by extrusion, rolling or forging, and finally heat-treated, before its properties are suitable for structural applications. The full heat-treatment is normally carried out in two stages: the first, "solution treatment," takes the alloying elements into solid solution by heating the metal to 520 deg. C. and then quenching rapidly. The properties can then be further enhanced by artificially ageing; by heating to 170 deg. C. for 10 hours, the alloying elements are precipitated as fine particles throughout the crystal structure.

For structural purposes, the alloy is used in the fully heat-treated (WP) condition unless severe forming of the section is required, when it may be necessary to bend the material in the more ductile solution-treated (W) condition. The alloy is available as extrusions, plate, sheet, wire and forgings, and is made by all aluminium firms under

proportionality, it is customary to quote the 0·1 per cent. proof stress, which is defined as "The stress that is just sufficient to produce a permanent elongation equal to 0·1 per cent. of a 2-in. gauge-length on a standard test piece." Though this value is an arbitrary one, it does give the designer some indication of when permanent distortion will be obtained. It will be seen from Table I that the guaranteed minimum 0·1 per cent. proof stress of HE10WP is 15 tons per square inch, and the typical value is 18 tons per square inch, figures that compare well with the yield point of structural steel.

Young's Modulus.—The value of Young's modulus is 9·5 × 10⁶ lb. per square inch, a figure roughly one-third of that for steel. Theoretical work on light-alloy members, confirmed later by tests both in America and the United Kingdom, has shown that this low stiffness raises problems that are not normally encountered with steel. Apart from the

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Fig. 2. FATIGUE CURVE FOR HE 10 WP.

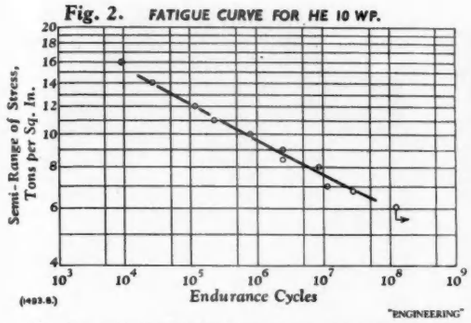
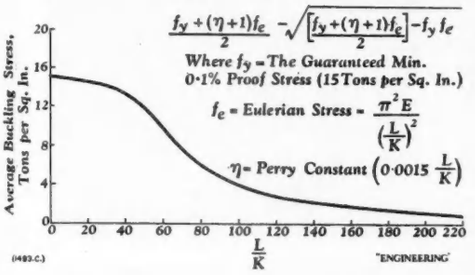


Fig. 3. PERRY-ROBERTSON STRUT CURVE FOR HE 10 WP.


Average Buckling Stress, Tons per Sq. In.
$\frac{f_y+(\eta+1)f_e}{2}-\sqrt{\left[\frac{f_y+(\eta+1)f_e}{2}\right]-f_y f_e}$
Where f_y = The Guaranteed Min. 0·1% Proof Stress (15 Tons per Sq. In.)
f_e = Eulerian Stress = $\frac{\pi^2 E}{\left(\frac{L}{K}\right)^2}$
η = Perry Constant $\left(0{\cdot}0015\ \frac{L}{K}\right)$
$\frac{L}{K}$
(4493-C.)
"ENGINEERING"

higher deflections that would be expected, alloy beams and compression members are prone to various forms of elastic instability, which have to be considered during design. As an understanding of the phenomena of instability is vital for the efficient design of compression members, the problem will be examined more fully later.

Resistance to Corrosion.—Pure aluminium is highly resistant to atmospheric attack and compares very favourably with other permanent building materials such as copper, lead and zinc, which it is now replacing for such purposes as flashings and fully-supported roofing. The resistance to corrosion generally tends to decrease with the increase of alloying elements, the effect varying considerably with the alloying metal. Magnesium and silicon, the two alloying elements in HE10, do not seriously affect the corrosion resistance properties, and in the majority of circumstances it is still vastly superior to structural steel. Where aluminium is in contact with dissimilar metals in a moist atmosphere, there may be danger of bimetallic corrosion unless the contacting surfaces are protected by a suitable inhibitive paint treatment. Provided that the recommended precautions are taken, there is little likelihood of any serious trouble occurring.

A great deal of work is being carried out on the expected life of HE10WP in various corrosive atmospheres, and the results obtained so far appear to be highly satisfactory. The rate of corrosion decreases rapidly with time, and the depth of penetration appears to be independent of thickness. It is particularly encouraging to note that, in many cases, HE10WP is being used instead of galvanised steel to enable maintenance costs to be reduced. This high durability of HE10WP enables smaller section thicknesses to be used than is normal in steel practice. This is acknowledged by the Institution of Structural Engineers, who in their report, mentioned above, suggest that sections with thicknesses down to 0·080 in. are sufficient for stress-carrying members.

Density.—The density of HE10WP is 0·098 lb. per cubic inch, as compared with 0·284 lb. per cubic inch for steel—nearly one-third the value. This low density, coupled with the medium-strength properties of HE10WP, gives it a much better strength/weight ratio than that possessed by structural steel. Full advantage cannot be taken of this strength/weight ratio, however, because of the lower Young's modulus, which necessitates an increased area for strut members. By careful design, it should generally be possible to produce

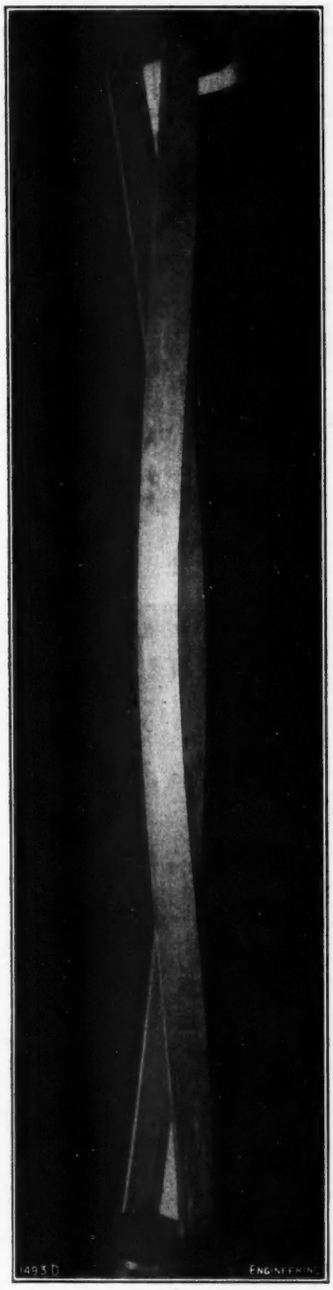


FIG. 4. TORSIONAL FAILURE OF A CHANNEL.

an aluminium structure 40 to 45 per cent. the weight of a steel equivalent, though, in certain cases, greater savings than this can be obtained, as the reduced thicknesses permitted for aluminium sections tend to offset the disadvantages of the lower modulus. C. Marsh, in his paper on "Aluminium as a Structural Material,"* gives examples of aluminium roof trusses which have been designed and constructed to weigh one-fifth that of their steel counterparts.

Elongation.—The typical elongation figure for HE10WP is 13 per cent. on a 2 in. gauge-length, which, though on the low side by conventional standards, is not so low as to jeopardise the safety of a structure. The greatest need for good elongation is at the joints, where a certain amount of stress redistribution is unavoidable, and Professor Redshaw* has shown that the elongation obtained with HE10WP is more than adequate to allow the necessary stress redistribution in plates and rivets. Possibly the most convincing evidence that the order of elongation is ample is found in current aircraft structures, where aluminium alloys are being successfully employed with higher proof-stress/ultimate-stress ratios and considerably smaller elongations than HE10WP. It is doubtful, in any case, whether the average structure would ever be required to withstand general elongations of over 2 per cent. before ultimate failure ensued.

Fatigue.—The fatigue strength of HE10WP (see Fig. 2, herewith) for zero mean stress is given as 6½ tons per square inch for 50 million cycles (the S/N curve shows that, unlike steel, there is no definite fatigue limit and the fatigue strength is therefore quoted for this high arbitrary number of reversals). Considerable emphasis has been given recently to the question of fatigue in aircraft, and has resulted in many unfounded fears. An investigation by the Society of British Aircraft Constructors showed that the only cases of fatigue failure in war-time aircraft were those that were accounted for by bad detailing, leading to high stress concentrations. The ratio of ultimate strength to fatigue strength for the aircraft alloy was approximately 2·9, compared with 2·7 for HE10WP, and, as the aircraft structures were also designed on static strength, fatigue failure of HE10WP structures is even less likely. Its fatigue strength is therefore much more than sufficient for most types of structures, which are not normally subjected to a large number of reversed loadings of any magnitude.

DESIGN PROBLEMS.

An examination of the properties of HE10WP has shown that the structural engineer is confronted with a material that is different in many respects from those at present in use, and, before it is possible to produce efficient light-alloy structures, it is necessary to examine these properties and see how they may affect the design. Probably the most significant problems are those presented by the comparatively low Young's modulus, which produces design problems to which the ordinary user of steel is unaccustomed.

Deflections.—Owing to this low Young's modulus, aluminium structures have larger deflections than are normally encountered in steel and, though the stresses in an HE10WP beam may be below the permissible working stresses, the deflections may still be excessive. It is necessary, therefore, to calculate the deflections of members and frameworks particularly where structures are being subjected to reverse loadings, as it is the deflections that ultimately govern the natural frequency of the structure. The tendency is, therefore, to deepen the beams and to use deep lattice frames where plate girders would be used in steel practice. In many cases, the deflections permitted in the various Codes and Specifications are those that are normally met in well-designed steel structures, and have no real structural significance. Aluminium structures, with their lower stiffness, are handicapped by these clauses, which, it is hoped, will be revised to accommodate the higher deflections that may be permissible with aluminium. Higher deflections and lower modulus are beneficial in one respect, however, as they allow structures to absorb higher impact forces than is possible with other types of material.

Instability Problems.—A compression member subjected to axial loading may fail in one of three ways: namely, by overall buckling, in which the column bends as a whole in the plane perpendicular to the axis of minimum moment of inertia; by local buckling, in which some part of the section buckles under compression; or by torsional buckling, in which the centre portion of the column rotates with respect to the ends. The type of failure depends upon the geometry of the cross-section, the slenderness ratio and the modulus of elasticity of the material. In the majority of cases, it is possible to consider these types of failure separately, failure

* Society of Engineers, April, 1949.

* "The Design Characteristics of Aluminium Riveted Joints," by S. C. Redshaw. Aluminium Development Association Symposium on Welding and Riveting Larger Aluminium Structures, November, 1951.

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occurring by the type of buckling that gives the lowest crippling load.

In the case of unsymmetrical sections, however, there may be an interaction of torsion with overall flexure, which may reduce the failing load of the strut, but, fortunately, this phenomenon does not affect the more standard type of sections to any serious extent. The Young's modulus of steel, coupled with the geometry of standard sections, is such that failure almost invariably occurs by overall flexure, and, therefore, the steel designer has had very little experience of the other forms of compressive failure. In the case of aluminium, however, it is possible that, owing to the reduced stiffness, one or other of these instabilities can occur even in sections of conventional type.

Overall Flexural Buckling.—A strut of compact cross-section will fail by overall Eulerian buckling. Experimental work was carried out after the war by Baker and Roderick* at the University of Cambridge, on a range of typical light-alloy sections, so that suitable strut curves could be obtained. It was found that, provided the sections were compact, failure could be predicted by the Perry-Robertson formula if the 0·1 per cent. proof stress of the material were used in place of the yield stress. To obtain complete agreement, it was necessary to vary the value of the Perry constant for different alloys, and accurate values of this constant were obtained for all the important structural alloys. These are now included in the report of the Institution of Structural Engineers' Report, previously cited, from which the Perry-Robertson curve for HE10WP, shown in Fig. 3, on page 763, was obtained. During the tests by Baker and Roderick, it was confirmed that instabilities other than overall flexural failure could occur with standard-type sections, and a full understanding of their behaviour is therefore very necessary.

Torsional Failure.—Experience on aircraft structures and recent experimental work, both in Cambridge and America, have shown that torsional failure can occur in a large number of aluminium sections. In this form of failure, which is illustrated in Fig. 4, on page 763, the axial load causes twisting of the centre relatively to the ends until the strut is incapable of carrying any further load. Owing to the non-occurrence of twisting in steel sections, very little work has been carried out on this problem until recently, when its full significance in light-alloy design had been realised. Work has since been carried out at both Bristol University and King's College, Newcastle-on-Tyne, and though there is still much to be learned, many of the difficulties appear to have been partly solved. The compressive stress at which pure twisting of a section will occur is given by:

$$p_t = \frac{G\,J}{I\,p} + \frac{\pi^2\,E\,W}{L^2\,I_p},$$

where G = shear modulus ($3{\cdot}8 \times 10^6$ lb. per square inch), J = torsion constant, W = warping constant, and I_p = polar moment of inertia about the centre of twist.

The second term in the formula allows for the warping restraint offered by the section to twisting, and will depend upon the geometry of the section and on the type of end-fixing employed. Except for very short struts, it is a secondary effect and a first approximation to the failing load can be obtained by considering the first term only. It can be seen from examination of this term that the torsional crippling stress is affected by the ratio of torsional stiffness to the polar moment of inertia. For circular sections these would be the same, but, as an open section becomes thinner, the value of J becomes very small compared with I_p, and the value of the torsional failing stress can then fall below the crippling stress for overall flexural failure.

To calculate this form of instability, it is necessary, therefore, to obtain an accurate value of the torsion constant of a thin open section. It is possible to obtain the correct theoretical value by the application of Southwell's relaxation methods, but, as this is extremely laborious, work to develop simpler methods is being carried out at Bristol and Newcastle. The most convenient method is to break the section into separate parts and to obtain the torsion constant by adding to the torsional values of the component rectangles additional terms due to the junction fillets and stiffening bulbs. Cullimore and Pugsley* have established formulæ for the stiffening effects of fillets, based upon the experimental work, and an amendment to B.S. 1161 has been issued, giving torsional constants for all the standard aluminium sections. Similar work is not yet available for bulbs and lips, but it appears that the membrane analogy suggested by Griffith and Taylor† gives reasonable agreement with the accurate relaxation solution. The torsional constant of bulbs and fillets is proportional to the fourth power of the inscribed circle, and greatly increased torsional stiffness can be obtained by the addition of comparatively small amounts of material in the form of bulbs and fillets. This is illustrated in Fig. 5, herewith, which shows the increase in the torsional stiffness of an equal angle that can be obtained by increasing the size of root fillet.

Fig. 5.

EFFECT OF FILLET RADIUS ON TORSION CONSTANT.

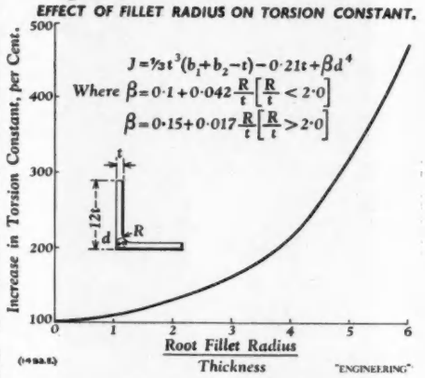
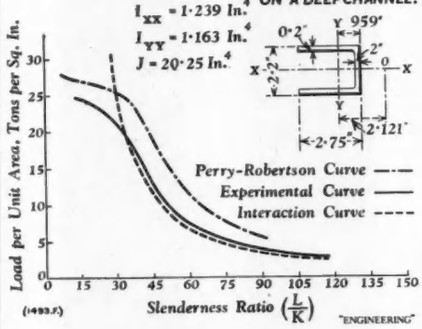


Fig. 6. *INTERACTION OF FLEXURE AND TORSION ON A DEEP CHANNEL.*



In sections with two planes of symmetry, the flexural and torsional failures are quite independent, and collapse will occur at whichever gives the lowest crippling load. The majority of structural sections have only one plane of symmetry, and, in this case, bending perpendicular to the plane of symmetry will cause twisting above the shear centre, which will interact with the flexure and may reduce the buckling load of the strut. This effect was shown in the results that Baker and Roderick‡ obtained on light-alloy sections, and Fig. 6, herewith, shows the variation between the experimental buckling curve for a deep channel and the Perry-Robertson solution. This interaction has been accounted for theoretically by Timoshenko,* who gives the following general formula for failure of struts with one plane of symmetry:

$$(P - P_1)[r_0^2\,(P - P_2)\,(P - P_3) - x_0^2 P^2] = 0,$$

where P = buckling stress; x_0 = distance of centre of gravity to centre of twist; P_1 = Eulerian stress in the plane of symmetry; P_2 = Eulerian stress perpendicular to the plane of symmetry; P_3 = torsional failing stress; and r_0 = polar moment radius of gyration about the centre of twist.

Solution of this equation gives two valid roots: the first is that required to cause overall flexural failure in the plane of symmetry, and the second is the buckling load due to the combined action of torsion with flexure perpendicular to the plane of symmetry. For equal angles and shallow channels, failure will occur either by flexure in the plane of symmetry or by torsion, which will be practically unaffected by the interaction of flexure. With deep channels, serious interaction may be experienced, the flexural failing load perpendicular to the plane of symmetry being reduced below that in the plane of symmetry.

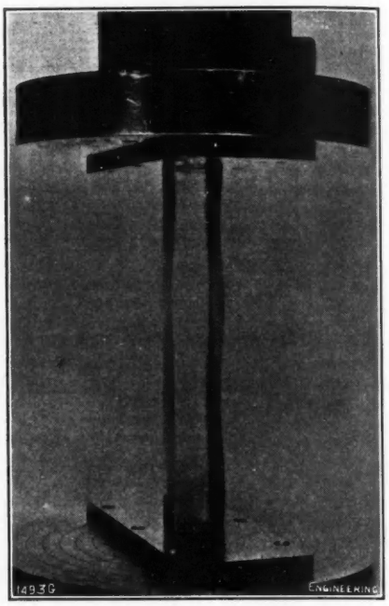


FIG. 7. LOCAL FAILURE OF A CHANNEL.

Local Buckling.—The low stiffness of aluminium may lead to local compressive buckling at stresses less than those needed to cause flexural failure. This type of failure is illustrated in Fig. 7, herewith, and takes the form of local buckles or wrinkles; although it does not lead to immediate collapse of the member, its occurrence is normally avoided for the sake of appearance.

The compressive load necessary to cause local failure is virtually independent of the length of member and depends only upon the amount of restraint that is applied to the plate by the rest of the section. The buckling load can be conveniently expressed as:

$$f_c = 0{\cdot}923\,KE\left(\frac{b}{t}\right)^2,$$

where K is a constant depending upon the degree of restraint. Values of K for standard sections have been given by the American Society of Civil Engineers,† based upon stiffness tables produced by Lundquist, Stowell and Schuetter, and are shown in Fig. 8, opposite. It is interesting to note that, for an angle with no fillet radius, the theoretical

* "The Strength of Light-Alloy Struts," by Professor J. F. Baker and J. W. Roderick. *A.D.A. Research Report No.* 3.

* "The Torsion of Aluminium Structural Members," by M. S. G. Cullimore and A. G. Pugsley. *A.D.A. Research Report No.* 9.

† "The Use of Soap Films in Solving Torsion Problems," by A. A. Griffith and Professor G. I. Taylor, *Proc. I. Mech. E.*, 1917, page 755.

‡ *Loc. cit.*

* "The Theory of Bending, Torsion and Buckling of Thin-Walled Members of Open Cross-Section," by S. Timoshenko. *Jl. Franklin Inst.*, 1945.

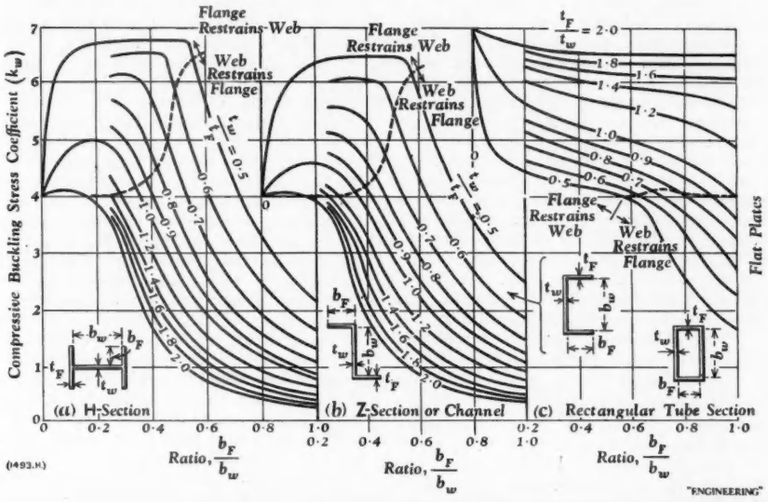
† "Buckling Stresses for Flat Plates and Sections," by E. Z. Stowell, G. J. Heimerl, C. Libove and E. E. Lundquist. *Proc. Amer. Soc. C.E.*, vol. 77 (Separate 77) (1951)

ALUMINIUM AS A STRUCTURAL MATERIAL.

Fig. 8. DETERMINATION OF LOCAL BUCKLING STRESS.

Local Buckling Stress $p_c = 0{\cdot}923\, k_w E \left(\frac{t}{b}\right)^2$

Where k_w is Obtained from the Appropriate Graph



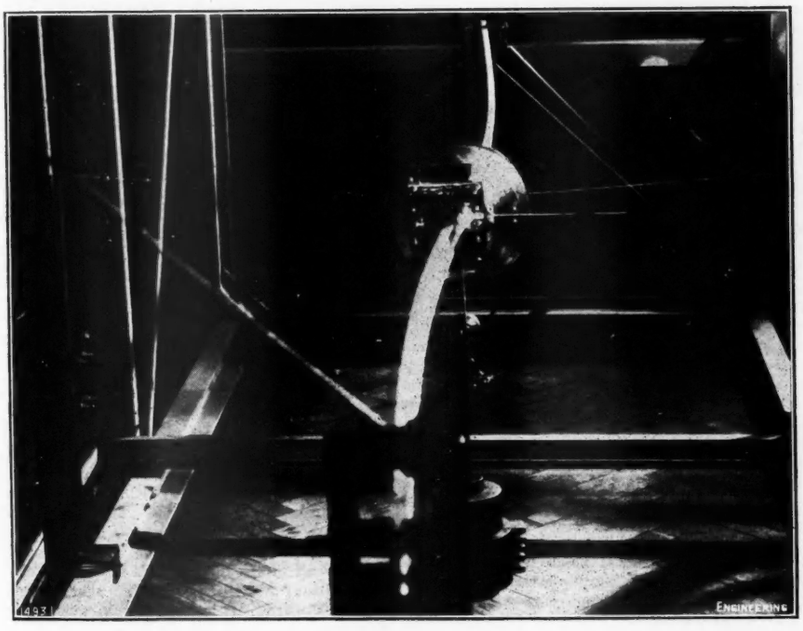


FIG. 9. LATERAL INSTABILITY OF A RESTRAINED I-BEAM.

value of the local buckling stress is the same as that required to cause torsional failure. Sections can be stiffened against local failure by the addition of lips and fillet radii, but the exact degree of restraint obtained by these methods does not seem to be easily predictable at present, although work is being carried out on this problem.

Lateral Instability.—The general phenomenon of lateral instability that is encountered with an unrestrained slender beam is accentuated with the use of aluminium alloy. Empirical rules have been adopted to prevent this type of failure in steel sections and the recent B.S. CP113 gives more rational rules for its prevention. The Institution of Structural Engineers' report on the structural use of aluminium alloys gives proposals for preventing instability in light-alloy beams by limiting the ratio of the width of flange to the unsupported span, the value of 1/17 being given for HE10WP. The influence of the warping restraint, the type of loading and the position of the point of application of the load relative to the shear centre appreciably affect the critical stress, and under certain conditions of loading the Institution of Structural Engineers' recommendations become extremely conservative.

Flint* has carried out extensive research work on this problem and, as a result, has suggested design rules, for both light-alloy I beams and channel sections, that would allow more economic detailing without any excessive calculation. These proposals allow for various loading conditions and offer a simple method of allowing for the warping restraint. An interesting result of experimental work was the effect the small lateral restraints had on the critical buckling load, the frictional restraint of cross-beams resting on the top flange being sufficient to raise the critical load by a considerable amount. A tight piano wire, attached laterally to the centre of the beam shown in Fig. 9, herewith, prevented overall bowing of the beam and caused buckling at twice the critical load, the beam bowing with a node at the middle of the span.

The general theoretical solution of the lateral instability stress is given by:

$$fc = \frac{C}{Z_x L}\frac{EI_1GJ}{\gamma}\left[1 + \frac{\alpha\pi^2 W}{GJL^2}\right]^{\frac{1}{2}},$$

where α = end restraint constant, $\gamma = \frac{I_2 - I_1}{I_2}$; W = warping constant; and C = load factor.

To prevent the occurrence of instability, sections with a high J or nearly equal moments of inertia should be used. This can be achieved, as in the case of strut members, by the addition of bulbs and fillets, by the adoption of hollow sections, or by the use of double members.

(To be continued.)

* "The Lateral Stability of Unrestrained Beams," by A. R. Flint. ENGINEERING, vol. 173, pages 65 and 99 (1952).

LAUNCHES AND TRIAL TRIPS.

S.S. "FIGHTING COCK" and "GAME COCK."—Single-screw tugs, built and engined by Cammell Laird & Co., Ltd., Birkenhead, for North West Tugs, Liverpool, for service on the Mersey. Main dimensions of both vessels: 105 ft. 9 in. by 26 ft. 9 in. by 13 ft. 3 in.; draught, 11 ft. 6 in. Each vessel propelled by a triple-expansion engine developing 1,200 i.h.p. Launch (both vessels), May 12.

S.S. "ARCADIA."—Twin-screw liner, with accommodation for 670 first-class and 735 tourist-class passengers, built and engined by John Brown & Co., Ltd., Clydebank, for the Peninsular and Oriental Steam Navigation Company, London, E.C.3. Main dimensions: 718 ft. by 90 ft. 6 in. by 50 ft.; cargo deadweight capacity, 6,150 tons; draught, 30 ft. 3 in.; gross tonnage, 28,000. Single-reduction geared turbines developing 42,500 s.h.p. Service speed, 22 knots. See also page 659, *ante*. Launch, May 14.

S.S. "ORSOVA."—Twin-screw liner with accommodation for 685 first-class and 813 tourist-class passengers, built and engined by Vickers-Armstrongs Ltd., Barrow-in-Furness, for the Orient Steam Navigation Co., Ltd., London, E.C.2. Main dimensions: 722 ft. 9 in. overall by 90 ft. 6 in. by 50 ft. to "E" deck; draught, 30 ft. 9 in.; gross tonnage, 28,200. Parsons-type geared turbines of Pametrada design developing 42,500 s.h.p. at 140 r.p.m. Service speed, 22½ knots. See also page 659, *ante*. Launch, May 14.

M.S. "CYMRIC."—Twin-screw refrigerated-cargo vessel, built and engined by Harland and Wolff, Ltd., Belfast, for the Shaw Savill and Albion Co., Ltd., London, E.C.3. Second vessel of an order for two. Main dimensions: 481 ft. between perpendiculars by 69 ft. by 41 ft. 6 in. to shelter deck; gross tonnage, about 10,800. Two single-acting two-stroke opposed-piston Diesel engines. Trial trip, May 14 and 15.

M.S. "ATLANTIC LORD."—Single-screw oil tanker, built by the Furness Shipbuilding Co., Ltd., Haverton Hill, County Durham, for Mr. S. G. Livanos, London, E.C.3. Second vessel for this owner. Main dimensions: 525 ft. between perpendiculars by 71 ft. by 39 ft. 3 in.; deadweight capacity, 18,080 tons on a summer draught of 30 ft. 6 in.; oil-tank capacity, 17,000 tons. Wallsend-Doxford six-cylinder two-stroke heavy-oil engine, developing 7,600 b.h.p. at 117 r.p.m., constructed by Wallsend Slipway and Engineering Co., Ltd., Wallsend-on-Tyne. Speed, 15½ knots. Trial trip, May 18.

M.S. "NORDELITE."—Single-screw trawler, built by the Goole Shipbuilding and Repairing Co., Ltd., Goole, for North Eastern Fish Industries, Ltd., Harbour Grace, Newfoundland. Main dimensions: 105 ft. by 23 ft. 6 in. by 11 ft. 6 in. Diesel engine, developing 450 b.h.p. at 310 r.p.m., constructed by Crossley Brothers, Ltd., Openshaw, Manchester, 11. Trial trip, May 19.

M.S. "BRITISH OAK."—Single-screw oil tanker, built by Smith's Dock Co., Ltd., South Bank-on-Tees, for the British Tanker Co., Ltd., London, E.C.2. Main dimensions: 515 ft. between perpendiculars by 69 ft. 6 in. by 37 ft. 6 in.; deadweight capacity, about 16,100 tons on a draught of 30 ft. 1 in. Six-cylinder two-stroke opposed-piston Diesel engine, developing 6,400 b.h.p. at 114 r.p.m., constructed by Harland and Wolff, Ltd., Belfast. Service speed, 13¾ knots. Launch, May 28.

S.S. "MOIRA."—Single-screw cargo vessel, built and engined by William Gray & Co., Ltd., West Hartlepool, for Dampskibsselskapet Marna, A./S., Oslo, Norway. Main dimensions: 310 ft. between perpendiculars by 46 ft. 10 in. by 27 ft. 10½ in. to shelter deck; deadweight capacity, 3,450 tons on a draught of 19 ft. Triple-expansion steam engine and two oil-fired boilers. Speed in service, 12 knots. Launch, May 29.

ELECTRICITY AND NATIONAL PROSPERITY.*

By Colonel B. H. LEESON, O.B.E., T.D., M.I.E.E.

AFTER seven years of austerity, and despite the efforts that have been made, Britain's economic stability has not been secured and she has passed from crisis to crisis. The shortage of coal is without doubt a principal cause of our economic unstability, but of no less importance is the decline in the intensity of human effort—in the broadest sense of every form of human endeavour. As a result, there have been shortages in every direction and in production generally, which with other factors has induced an alternating notching up of costs and wages with virtually no lasting benefit to anyone—unless it be to our foreign competitors. This inflationary effort has brought about lower standards of life to many and there will be a tendency for it to spread unless counteracted by greater human effort. In short, Britain has been living on her reserves, which are now critically depleted; and unless we pay our way our standard of living is in jeopardy. The challenge that faces the nation to-day is therefore that of re-orientating our productive effort, so that it may take account of the basic changes in world economy and dovetail into the world's demand.

The country's economic position is set out clearly in the Government's annual *Economic Surveys*. Last year the most urgent problem was how to stem the drain on our gold and dollar reserves. To restore stability, imports were cut down and this, coupled with better terms of trade and the export drive, resulted in a favourable trade balance and an escape from a calamitous situation. This, however, could only be regarded as a breathing space during which to organise remedial measures of a more permanent character. Steps must therefore be taken to pass from the surgery of import cuts to the necessary cure of freeing and creating (not handicapping) greater world-wide trade. An adequate external balance must also be maintained and economic stability directed to further advancement in the world economy. In fact, Britain must pay her way by Government and industry collaborating to increase her volume of exports. To assist towards this end the electrical industry is ready to re-equip industries and by other means improve their ability to export against growing world competition.

WORLD ECONOMY.

The primary need in world economy to-day is for a rapid expansion in the supply of food and raw materials, in order to raise the standard of living of a population which is expanding at a remarkable rate. Economic development is thus recognised by every responsible Government as a necessity for national expansion; and enormous demands for capital goods can be foreseen in countries like Canada, Australia and India. Unfortunately, many of the rapidly developing countries have overstretched their resources, while others, like ourselves, have been importing more than they can afford. The result in both cases has been that retrenchment has been necessary. Much attention, too, has been given to developing the manufacture of secondary goods, which, by improvements in technique and international competition, have tended to become cheaper. Insufficient action has been taken to increase the production of primary goods, like food and raw materials, which have tended to become relatively dearer. This trend most vitally affects those countries which, like Britain, have based their economy on their manufacturing industries and are accustomed to living on the exchange of their products for foreign food and raw materials. We must therefore concentrate our efforts on producing goods which are unsurpassed in quality, and our inherent skill and craftsmanship must thus be made to yield increased dividends from the world's markets.

It is therefore clear that Britain must develop an economy which will ensure her a continuously favourable balance of trade and is not too vulnerable to external booms and slumps. This calls for a redoubling of our efforts to produce more food and raw materials from our own resources and so to save imports. Next to the land, Britain's coal deposits are her most important primary asset. The supply is, however, falling far behind the potential demand and the necessity of conserving it requires constant attention. Fuel efficiency must be further improved and technical progress in industries that could effect great savings in coal consumption must be speeded up. A simple example is railway electrification, which could achieve an annual saving of 10 million tons of high-grade coal per annum. Unhappily, coal exports have dwindled so seriously as to restrict our purchases of food and raw materials in many traditional markets. To restore the balance of overseas trade more manufactured goods have to be exported, thus increasing the home consumption of coal. The other major shortage in the British economy is food. The need for a bold, continuous and progressive agricultural policy is clear. The role of electricity in increasing the production of this vital need is not so much to accentuate the natural yield of Nature as to provide an attractive life for the people engaged in agriculture and to attract them to it.

CAPITAL AND SAVINGS.

In discussions on economic policy there is general agreement that if prosperity is to be increased more capital must be invested in the re-equipment and expansion of industry. It is also agreed that this more liberal investment must come from a larger volume of savings. In 1952, however, investment in plant and machinery fell to 775*l.* million, compared with 794*l.* million in 1951; and from 283*l.* million to 248*l.* million in vehicles, ships and aircraft. If this decline is continued, the effects on our industrial potential will be serious. Moreover, while in 1939 the Exchequer took about 17 per cent. of the net company income of the electrical industry, this figure had risen to 38 per cent. in 1951; while after company taxation and the payment of dividends the proportion of available income for ploughing back into the industry had dropped during the same period from 39 to 33 per cent. When the substantial fall in purchasing power during that period is considered, it is clear that industry is being drained of that reproductive capital which is so necessary for its expansion and development, and even for its very survival in view of the increasing world competition. The electricity supply industry, too, has a right to demand additional capital, for it has become one of the basic industries upon which the prosperity of our economy depends. To-day our best quality coal is required for domestic use and for export. With the increasing mechanisation of the mines, low-grade coal is forming a higher percentage of the total output and the generation of electricity is one of the most efficient means of utilising it.

Britain's wealth, however, lies in her people just as much as in her mineral resources. She needs a constant supply of high-grade scientists, technologists and technicians who are capable of being trained to play their part in the ever-widening fields of scientific and technical research that are so vital to industry. Research and development must be better organised so that scientific discoveries are more quickly applied and progress accelerated. One of the principal tools available for this purpose is electricity, which has conferred innumerable benefits upon us and is now applied to myriad forms of human activity. As a result, employment emanating from its development and application has reached a total of nearly 950,000 people, and over the last seven years 350,000 have been taken into the electrical power industry. It will be evident, therefore, that the electrical profession and industry are of great importance both in supplying the domestic and foreign markets and in providing the impetus to other industries to increase their efficiency and stimulate their exports.

POWER SUPPLIES ESSENTIAL.

In fact, as a result of invention and research the electrical industry is continually progressing and the most spectacular developments in productive efficiency have stemmed from the employment of its equipment. It provides the operator with invisible "slaves" which can perform work in a variety of ways which he himself would find impossible. It multiplies his manual capacity, places at his disposal additional forms of energy and extends the range of his senses far beyond their natural limitations. Moreover, it contributes to his health and well-being and to a standard of living unobtainable by other means. These advantages, however, throw added responsibilities on the shoulders of the individual, making good time-keeping and other forms of factory discipline essential.

It is clear, therefore, that if we are to increase productivity further the prime requirement is a plentiful supply of power. The problem which faces us in this connection is whether the capital allocation for supply equipment will be sufficient to take into account the rapidly increasing applications of electricity, the replacement of obsolescent plant to obtain fuel economy, and the need of industry for increased electrical horse-power. The average American worker has at his disposal up to three times the electrical horse-power available to the British worker. To assess the significance of this, however, the structure of industry in the two countries and their differing internal commercial conditions must be taken into account. Generally, American industry is designed to manufacture articles in large quantities which can be absorbed by the home market, whereas British industry can only sustain its standard of living by meeting the varied requirements from overseas markets for high-grade articles of many different varieties which sell on quality. The factories of the British electrical industry contain equipment second to none in the world, while its quantity-production methods are up to date, with a high figure of electricity consumption per worker. At the same time, it incorporates craftsmanship facilities for specialist high-grade products. It is in the number of smaller manufacturing units (which abound in Britain) that the picture is liable to be different and account for less electricity per worker.

At this time of crisis in the national economy, when efforts for productivity should be at their maximum, the early attainment of a yearly rate of plant installation of 2,000 MW is imperative. A capital investment policy allowing this rate of installation is a necessity to economic recovery, which cannot be stressed too greatly. The installation of new plant on this scale, in addition to supplying much needed extra power for industry, would also bring the advantage of an appreciable economy in coal by more rapid replacement of obsolete and inefficient plant.

ELECTRICAL MANUFACTURING INDUSTRY.

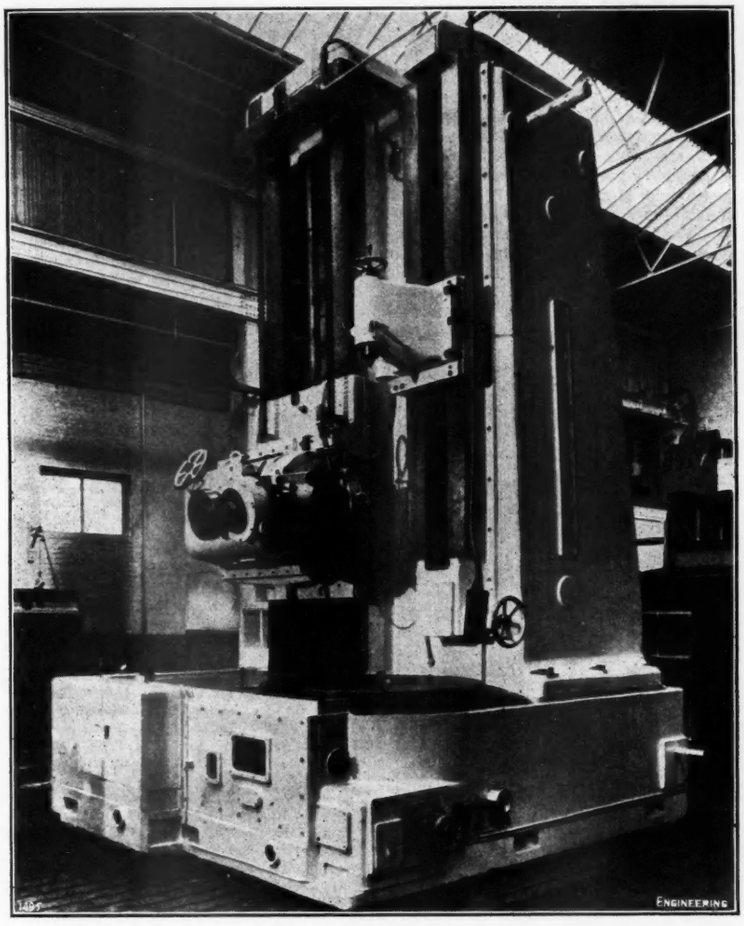
The British electrical manufacturing industry is now providing employment for nearly 600,000 people and it is illuminating to contrast its present strength and achievement with the weakness and struggles of its early years. This change is the result of voluntary co-operation between manufacturers, the success of which is demonstrated by the growth in the number and size of the firms in the industry and by its notable achievements all over the world. It can also be demonstrated by pointing out that the electrical industry ranks second among the country's exporting industries and by emphasising that, if account is taken of the large quantity of indirect exports in the form of electrical equipment incorporated in the products of other exporting industries, it is reasonable to suppose that over one-third of the industry's output is sent overseas. It is difficult to assess a figure with any accuracy, but the value of these products is certainly over, rather than under, 250*l.* million.

One of the fundamental requirements for the expansion of exports is that the industry concerned shall have a stable, progressive and resourceful home market. This market must be freed from all artificial handicaps, such as purchase tax and other restrictive controls, so that the manufacturer may have the necessary quantity production and other facilities that will place him in a position to compete with the world. The task of British industries in expanding their exports lies increasingly in their ability to supply products having the quality and performance that cannot be obtained from goods purchased elsewhere. Exports flourish as the result

* Paper read before the British Electrical Power Convention at Torquay on Tuesday, June 9, 1953. Abridged.

VERTICAL PINION-HOBBING MACHINE.

DAVID BROWN MACHINE TOOLS, LTD., MANCHESTER.



PINION-HOBBING MACHINE WITH VERTICAL AXIS.

THE 36-in. vertical pinion-hobbing machine shown in the accompanying illustration is part of a consignment of gear-cutting plant ordered by the Italian shipbuilding company, Ansaldo, of Genoa. It was made by David Brown Machine Tools, Limited, Manchester, and is the first vertical hobber of this size to be built by the makers; the machine weighs approximately 60 tons and will cut high-speed turbine pinions from 6 in. to 36 in. in diameter at a maximum diametral pitch of 1¼. The full height of the machine is 19 ft. 9 in. and it will accommodate pinions with shafts up to 12 ft. long. It is claimed by the makers that this departure from the conventional horizontal design has several advantages, the most important being that it obviates the difficulty of obtaining true alignment due to the deflection of the pinion under its own weight. One of the other features of the vertical design is that it achieves a considerable saving in floor space.

As in the normal wheel-hobbing machine, the axis of the table is vertical and in the same plane as the upright carrying the hob slide. This upright is extended in width to carry a work steady, the axis of which is in line with the axis of the table. By having the guides for the hob slide and pinion steady machined in the same plane on one solid casting, a high degree of accuracy in the alignment between the two sets of guides is achieved in a comparatively simple manner. Since the upright is fixed in relation to the axis of the table, alternative arrangements have had to be made to compensate for the variations in the diameters of the gear blanks. This is achieved by providing separate vertical slides for the work steady and the hob saddle, in which an in-feed hob slide is incorporated.

The machine comprises two main components, the bed and the upright. The bed, which is a large box-section casting, houses the gearbox and table seating, and the upright, which is a ribbed casting, carries the vertical guides for the hob slide and steady. The vertical traverse of the hob slide is driven by a 5 in. diameter screw that is mounted in the centre of the guideways, and the swivel slide pivots 45 deg. each way to enable right and left-hand helical teeth to be cut. The hob spindle is 4 in. in diameter and it has a conical bearing at the drive end. The drive is of the solid type and it embodies a fine-pitch dividing wormwheel, with teeth which are exceptionally long, to provide a larger contact area, improved accuracy, and a better surface finish. The diameter of the dividing wheel is approximately 54 in., which is almost twice the diameter of the largest pinion that can be cut on the machine; this reduces to a minimum the effect, on the finished pinion, of any minor pitch errors in the dividing wheel. All the driving gears to the dividing worm, the vertical hob-drive shafts, and the lead-screw are carried in a gearbox. The gear and shafts run on ball or roller bearings and forced-feed lubrication is provided. The main driving gears and shafts are made of high-tensile steel, and profile-ground spur gears are used in the differential drive. The maximum vertical traverse of hob at a 40-deg. helix angle is 100 in., the maximum diameter of the hob is 9 in. and the maximum length of the hob is 12 in. The hob speeds range from 12·5 r.p.m. to 58·5 r.p.m. and the range of vertical feeds per revolution of the table is 0·007 in. to 0·100 in.

The electrical gear comprises four motors, all of which are operated from a central push-button control box of the pendant type. The main motor has an output of 10 h.p. and gives speeds from 750 to 1,500 r.p.m. A 3-h.p. auxiliary motor provides the drive for the rapid traverse of the hob slide; a ¾-h.p. motor drives the automatic lubrication system, and a 1-h.p. motor provides the drive for the pump which supplies a continuous flow of cutting lubricant. The electrical equipment is arranged for 400/440 volts, 3 phase, 50 cycles, but it can also be arranged for direct-current supply. This machine, which occupies a floor space of 12 ft. 6 in. by 12 ft., is to be installed in a turbine-gear shop which is being equipped with David

of growing home demands, and more freedom in world trade is essential to a further expansion of our overseas markets.

TO-DAY'S CHALLENGE.

The upshot of the state of affairs that has been portrayed, particularly in relation to the major issue of national prosperity, is that the nation's economic system is struggling with insufficient reserves to maintain a precarious balance between what is put into it and what is demanded from it. The question is, how is the system to be balanced on a more permanent basis and restored to a state of stability and capacity so that it can supply our needs? Many of the ramifications of modern life are not clearly discernible. Hence, the methods that should be adopted to bring about recovery and prosperity are often difficult to perceive in clear perspective. One thing, however, is certain, that we face a challenge and a choice. Are we as individuals and as a nation content to accept with complacency the obvious trend of affairs towards a lower standard of living or, alternatively, shall we take up the challenge this represents and by courage and the exertion of more strenuous individual efforts on things that really matter change the trend towards recovery and better times for one and all? This is a human problem to which there can be only one answer. The challenge must be be met before it is too late.

The general lines on which this challenge needs to be taken up are clear in principle, although putting them into practice may involve many difficulties. They are more human effort; greater production of the basic commodities; more fuel and power for industry and the home; and more capital, that is, greater economy and savings by Government, industry and individuals. Expressed in another way, to retain our standard of living and improve our economic stability greater and more united efforts on things that really matter are necessary, in order to obtain greater output and trade from the country's available resources. This must be accomplished first in the primary industries, such as that of coal, in order to increase their output and trade. The beneficial effects would then extend to subsidiary industries and ultimately spread to all activities. In this way shortages would be transformed into sufficiencies, earnings into savings and capital reserves, and both economic stability and economic resources created. We should then be able to hasten forward our immediate and overdue projects, be they educational, industrial or commercial; to advance more energetically the application of scientific developments; and to explore thoroughly new sources of heat and and power. Matters of national economy are, however, so remote from the everyday life of most people that the problem is how to arouse public appreciation of the country's dire need. A clarion call to exert fuller efforts towards prosperity is therefore necessary, so that a deeper realisation of the country's economic need may be awakened in the minds of every citizen.

COMMONWEALTH AIR TRANSPORT COUNCIL.—The fourth meeting of the Commonwealth Air Transport Council was opened in London on Wednesday, June 10, by the Minister of Civil Aviation, the Rt. Hon. A. T. Lennox-Boyd. Among other matters, the Council will discuss problems of noise at airports, runway economy, and future lines of aircraft development.

Brown plant. Special foundations are being laid for the new shop, and it is to be temperature controlled throughout. The David Brown engineers have collaborated in the design of the installations and of the foundations for the machines. At the request of the customer, all the machines are to be painted a marigold yellow to harmonise with a general colour scheme of the shop, which has pale green walls and ceilings of "Mediterranean blue."

TRADE PUBLICATIONS.

Flue-Dust Precipitators.—We have received from Simon-Carves, Limited, Cheadle Heath, Stockport, one of the Simon Engineering Group, a brochure describing their electro-precipitation plant for the extraction of dust from flue and other industrial gases. The brochure illustrates these precipitators as now being applied to power stations of the British Electricity Authority, and notably to that at Huncoat, where precipitators have been completed and are now in operation.

Emergency Lighting Equipment.—The Tudor Accumulator Co., Ltd., 137, Victoria-street, London, S.W.1, have sent us pamphlets dealing with their "Safetylyte Major" and "Safetylyte Minor" emergency Lighting equipment.

Electric Motors.—Descriptions, illustrations, dimensions and output tables of the drip-proof slip-ring and squirrel-cage motors, manufactured by them for outputs up to 500 h.p., are contained in a brochure received from Newman Industries, Ltd., Yate, Bristol. A second leaflet deals with their totally-enclosed fan-cooled motors, which comply with draft British Standard Specification CN (ELE) 6814.

Diesel Crawler Tractor.—Details of the Challenger-3 Diesel crawler tractor fitted with timber extraction equipment, and made by John Fowler & Co. (Leeds), Ltd., Leeds, 10, are given in a leaflet published by them.

Boiler Feed Heaters.—We have received from G. & J. Weir, Limited, Glasgow, a brochure illustrating their boiler-feed heaters, which are manufactured in straight-tube and U-tube designs, for vertical and horizontal position. One heater illustrated has a capacity of 595,240 lb. per hour with working steam and water pressures of 136 lb. and 2,270 lb. per square inch, respectively.

Fractional Horse-Power Motors.—A leaflet received from Hoover, Ltd., 211, Regent-street, London, W.1, gives details of their fractional horse-power motors. The output of the "drip-proof" range extends from ⅛ to ¼ h.p. single-phase and up to ½ h.p. three-phase. A more limited range of totally-enclosed motors is also available.

Flameproof Direct-on Contactor Starter.—The Belmos Co., Ltd., Bellshill, Lanarkshire, have sent us a leaflet describing their 30-ampere flameproof direct-on contactor starter for electric motors.

Screwing Dies and Chasers.—Charles Winn & Co., Ltd., Granville-street, Birmingham, 1, have published a leaflet which lists the sizes of screwing dies and chasers stocked by them.

Anti-Vibration Mountings.—We have received an illustrated leaflet from Dunlop Special Products Ltd. (Eng. Comp. Divn.), Fort Dunlop, Birmingham, describing the application and the installation procedure for their anti-vibration mountings for heavy machinery.

Colloidal Graphite.—Acheson Colloids Ltd., 18, Pall Mall, London, S.W.1, makers of "Dag" colloidal graphite, have sent us a new edition of their booklet entitled "The Running In of Engines."

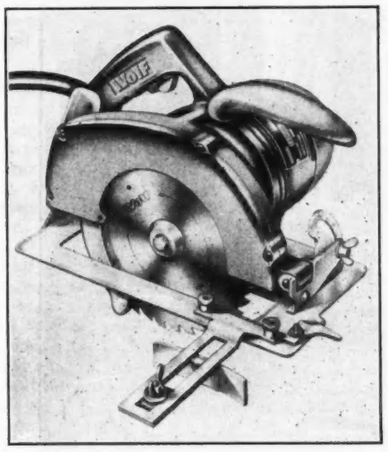
Belt-Lacing Equipment.—The Mastabar Belt Fastener Co., Ltd., Marfleet, Hull, have issued a new publication entitled "The Comet Manual." It illustrates the variety of belt-lacing equipment and accessories made by them.

Steam Power Plant Auxiliaries.—Apparatus for lifting and heating liquids, and for moving air and gases, as well as spray nozzles, spray cooling plants, condensers and accessories, are detailed in an illustrated catalogue issued recently by Korting Bros. (1917), Ltd., Sheep-bridge-lane, Mansfield, Notts. The principal items are steam-jet elevators, steam-jet water ejectors or bilge pumps, and sand and mud elevators; silent water heaters; water-jet pumps and elevators; steam-jet air compressors, ejectors, agitators, gas exhausters, chimney ventilators and blast nozzles; thermo-compressors; gas-producer and under-grate blowers; air-jet ventilators; single-jet and multi-jet condensers; a vacuum-breaker; check valves for condensers; a gland-steam condenser; and an obnoxious-vapour condenser. Requests for copies of the catalogue should be made on firms' letter headings.

Fluorescent Lighting Fittings.—The Edison Swan Electric Co., Ltd., 155, Charing Cross-road, London, W.C.2, have sent us particulars of their new 5-ft. "Unilux" fitting which has been designed for use with an 80-watt fluorescent lamp.

HEAVY-DUTY ELECTRIC HAND SAW.

THE 7-in. heavy-duty electric hand saw shown in the accompanying illustration is capable of cutting through 2-in. thick seasoned oak at a rate of 14 ft. per minute. The saw has a maximum vertical cut of 2$\frac{5}{16}$ in., which is reduced to 2 in. when the blade is canted over to make a 45-deg. bevel cut. With no load the blade speed is 4,200 revs. per minute and at maximum load, when the power consumption is 1,050 watts, the speed drops to 3,000 revs. per minute. The overall length of the heavy-gauge steel soleplate is 14½ in. and the net weight of the saw is 17¼ lb. A wide choice of universal motors can be supplied, to cover all likely direct-current and alternating-current mains; normal equipment supplied with each machine includes a starting switch, a 15-ft. length of 3-core T.R.S. cable, one combination rip-and-crosscut blade, a ripping guide, small tools and one spare pair of carbon brushes. Alternative blades include



a cross-cut for smoother cutting, and for a fine finish there is a planer blade. For cutting wall-board, the makers have provided a very fine-toothed blade and a friction blade is available for cutting plain and corrugated sheet metal up to 20 gauge in thickness. Cement, stonework and other ceramics can be cut most easily and rapidly by fitting an abrasive disc.

Made by Wolf Electric Tools, Limited, Hangar-lane, Ealing, London, W.5, the saw has been designed with care in order that operator fatigue shall be reduced to a minimum. The motor is mounted transversely and at right-angles to the blade, the drive being transmitted through nickel-chrome-molybdenum steel gears; all the principal shafts are mounted in ball bearings and all rotating parts have been dynamically balanced. Protection for the operator is given by a fixed shield over the top of the blade, the underside of which is guarded by a pressed-steel telescopic shield that retracts as the saw is offered to the workpiece. A volute moulding on the nearside of the blade shield, which causes the sawdust to be ejected at the rear of the machine behind the operator, ensures that the cutting line is kept clean and unobscured by dust. For convenient and safe transport of the saw, a steel carrying case is supplied as an accessory, the case also providing accommodation for extra cable and alternative blades.

INTRODUCTION OF BRISTOL "SUPERFREIGHTER" CAR FERRY.—Silver City Airways Ltd. have started their first air ferry for automobiles and passengers between London (Gatwick Airport) and Le Touquet. The entire journey, from Victoria Station to Le Touquet takes 100 minutes. The aircraft to be used are Bristol Super-freighters, six of which have been ordered. The Super-freighter, a development of the Bristol Freighter manufactured by the Bristol Aeroplane Co., Ltd., Filton, Bristol, with lengthened fuselage, carries three cars and 20 passengers. The aircraft, which has an all-up weight of 44,000 lb., is powered by two Bristol Hercules 734 engines.

BOOKS RECEIVED.

Sewerage and Sewage Treatment. By PROFESSOR HAROLD E. BABBITT. Seventh edition. John Wiley and Sons, Incorporated, 440, Fourth-avenue, New York 16, U.S.A. [Price 8 dols]; and Chapman and Hall, Limited, 37, Essex-street, London, W.C.2. [Price 64*s.* net.]

Prestressed Concrete. By Y. GUYON. Edited by W. M. JOHNS. Contractors Record and Municipal Engineering, Lennox House, Norfolk-street, London, W.C.2. [Price 70*s.*]

Handbook on Track Laying for Underground Haulage. The National Coal Board Production Department, Hobart House, Grosvenor-place, London, S.W.1. [Price 5*s.* 6*d.*, post free.]

Public Health Engineering. By PETER C. G. ISAAC. E. and F. N. Spon, Limited, 22, Henrietta-street, London, W.C.2. [Price 36*s.* net.]

United Nations Economic and Social Council. European Steel Exports and Steel Demand in Non-European Countries. Prepared by the Industry Division, Economic Commission for Europe. United Nations, Palais des Nations, Geneva, Switzerland. [Price 9*s.*, or 1.25 dols, or 5 Swiss francs.]

Differential and Integral Calculus. By PROFESSOR PHILIP FRANKLIN. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York 36, U.S.A. [Price 6 dols.]; and McGraw-Hill Publishing Company, Limited, 95, Farringdon-street, London, E.C.4. [Price 48*s.*]

The Earnings of Industry. Hollis and Carter, Limited, 25, Ashley-place, London, S.W.1. [Price 4*s.*]

Specifications for the Construction of Housing Estate Roads Using Soil-Cement. Road Research Note No. 15. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 9*d.* net.]

An Investigation into the Plastic Bending of Aluminium Alloy Beams. By J. B. DWIGHT. Aluminium Development Association, 33, Grosvenor-street, London, W.1. [Price 7*s.* 6*d.*]

British Petroleum Equipment, 1953. The Council of British Manufacturers of Petroleum Equipment, 79, Buckingham Palace-road, London, S.W.1. [Price 50*s.*]

The College of Aeronautics, Cranfield. Report No. 69. *Some Experiments on the Flow in the Boundary Layer of a 45 deg. Sweptback Untapered Wing of Aspect Ratio 4.* By K. EMSLIE, L. HOSKING, and W. S. D. MARSHALL. The Librarian, The College of Aeronautics, Cranfield, Bletchley, Buckinghamshire. [Price 5*s.*]

Introductory Engineering Materials. By PROFESSORS IRVING H. COWDREY and EDWARD R. BARTHOLOMEW, Jr. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York 36, U.S.A. [Price 6 dols]; and McGraw-Hill Publishing Company, Limited, 95, Farringdon-street, London, E.C.4. [Price 48*s.*]

Information Theory and its Engineering Applications. By D. A. BELL. Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.2. [Price 20*s.* net.]

Production of Drilling and Refining Oil Equipment in the U.S.A. The Organisation for European Economic Co-Operation, 2, Rue André-Pascal, Paris (16e). [Price 10*s.*, or 500 francs.]

Report of the Food Investigation Board with the Report of the Director of Food Investigation for the Year 1952. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 2*s.* net.]

Flammspritzen. Beuth-Vertrieb G.m.b.H., Auguste-Viktoria-Strasse 66, Berlin-Schmargendorf, Germany. [Price 5.90 D.M.]

The Principles and Practice of Management. Edited by E. F. L. BRECH. Longmans, Green and Company, Limited, 6 and 7, Clifford-street, London, W.1. [Price 50*s.* net.]

Water Supply and Sewerage. By PROFESSOR ERNEST W. STEEL. Third edition. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York 36, U.S.A. [Price 8 dols.]; and McGraw-Hill Publishing Company, Limited, 95, Farringdon-street, London, E.C.4. [Price 64*s.*]

Export. A Handbook of Export Procedure. Engineering Industries Association, 9, Seymour-street, London, W.1. [Price 3*s.* 6*d.*]

Radio Designer's Handbook. Edited by F. LANGFORD-SMITH. Fourth edition. Iliffe and Sons, Limited, Dorset House, Stamford-street, London, S.E.1. [Price 42*s.* net.]

United States National Bureau of Standards. Miscellaneous Publication No. 206. *Report of the Thirty-Seventh National Conference on Weights and Measures.* Washington, D.C., May 20, 21, 22, and 23, 1952. The Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., U.S.A. [Price 40 cents.]

Facts, Files and Action in Business and Public Affairs. By DR. J. EDWIN HOLMSTROM. Part 2. *Filing, Indexing and Circulation.* Chapman and Hall, Limited, 37, Essex-street, London, W.C.2. [Price 32*s.*]